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Nakajima et al.

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(54) **LIQUID EJECTING APPARATUS AND METHOD OF DRIVING THE SAME**

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(51) **Int. Cl.**

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B41J 2/14	(2006.01)
B41J 2/19	(2006.01)
B41J 2/045	(2006.01)

(52) **U.S. Cl.**

CPC ***B41J 2/17563*** (2013.01); ***B41J 2/04581*** (2013.01); ***B41J 2/14233*** (2013.01); ***B41J 2/175*** (2013.01); ***B41J 2/17596*** (2013.01); ***B41J 2/19*** (2013.01); *B41J 2002/14241* (2013.01); *B41J 2002/14419* (2013.01); *B41J 2202/07* (2013.01); *B41J 2202/11* (2013.01); *B41J 2202/12* (2013.01)

(58) **Field of Classification Search**

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See application file for complete search history.

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(57) **ABSTRACT**

A liquid ejecting apparatus includes a liquid path comprising a filter and a liquid storing chamber for supplying liquid to a liquid ejecting head. The liquid storing chamber has an inlet, a bubble retention space disposed above the inlet, a bottom disposed below the bubble retention space, and a first outlet and a second outlet. (i) The first outlet is located on one side of an imaginary center line passing through the center of a projected area, and the second outlet is located on the other side of the imaginary center line. Alternatively, (ii) the first outlet and the second outlet are located outside a projected area defined by projecting the bubble retention space onto the bottom.

20 Claims, 14 Drawing Sheets

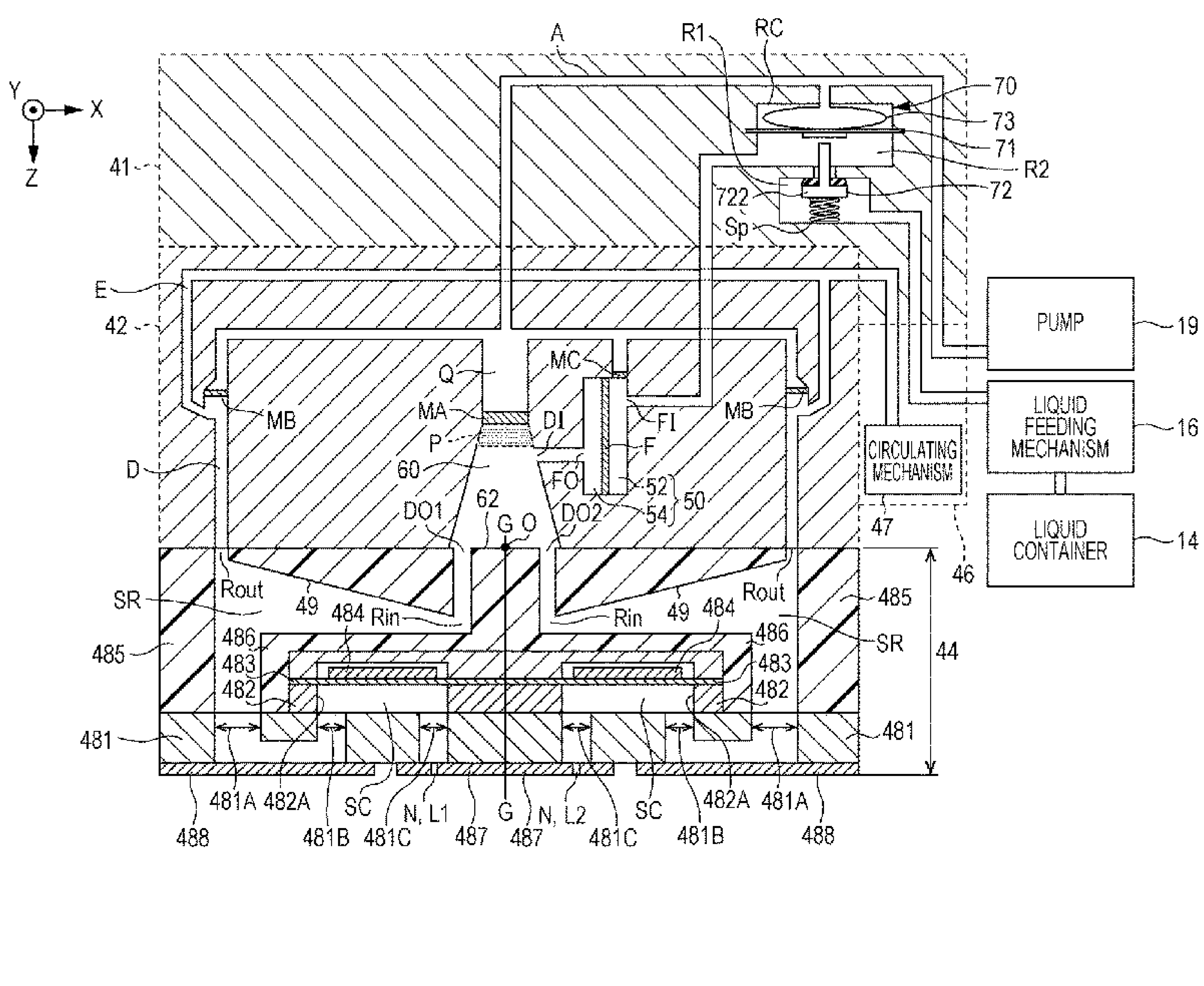


FIG. 1

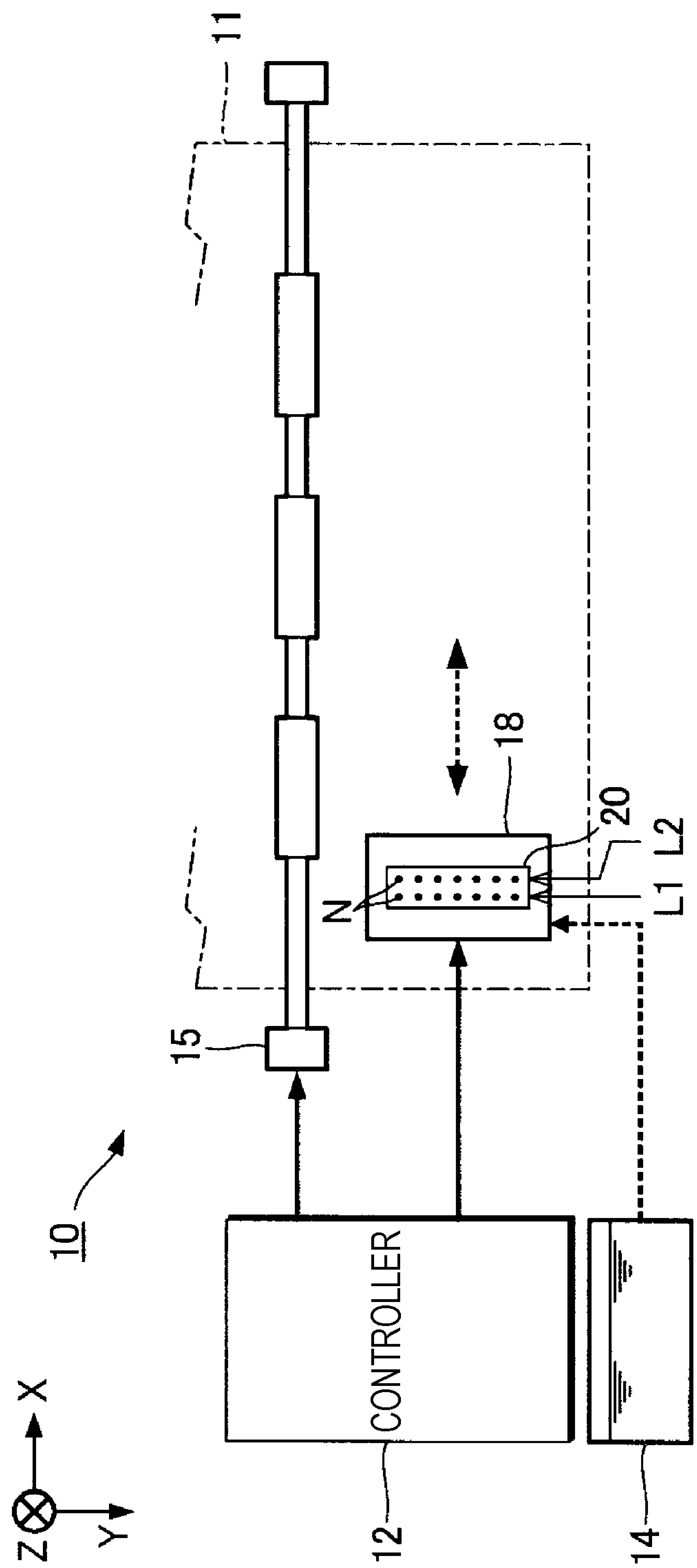
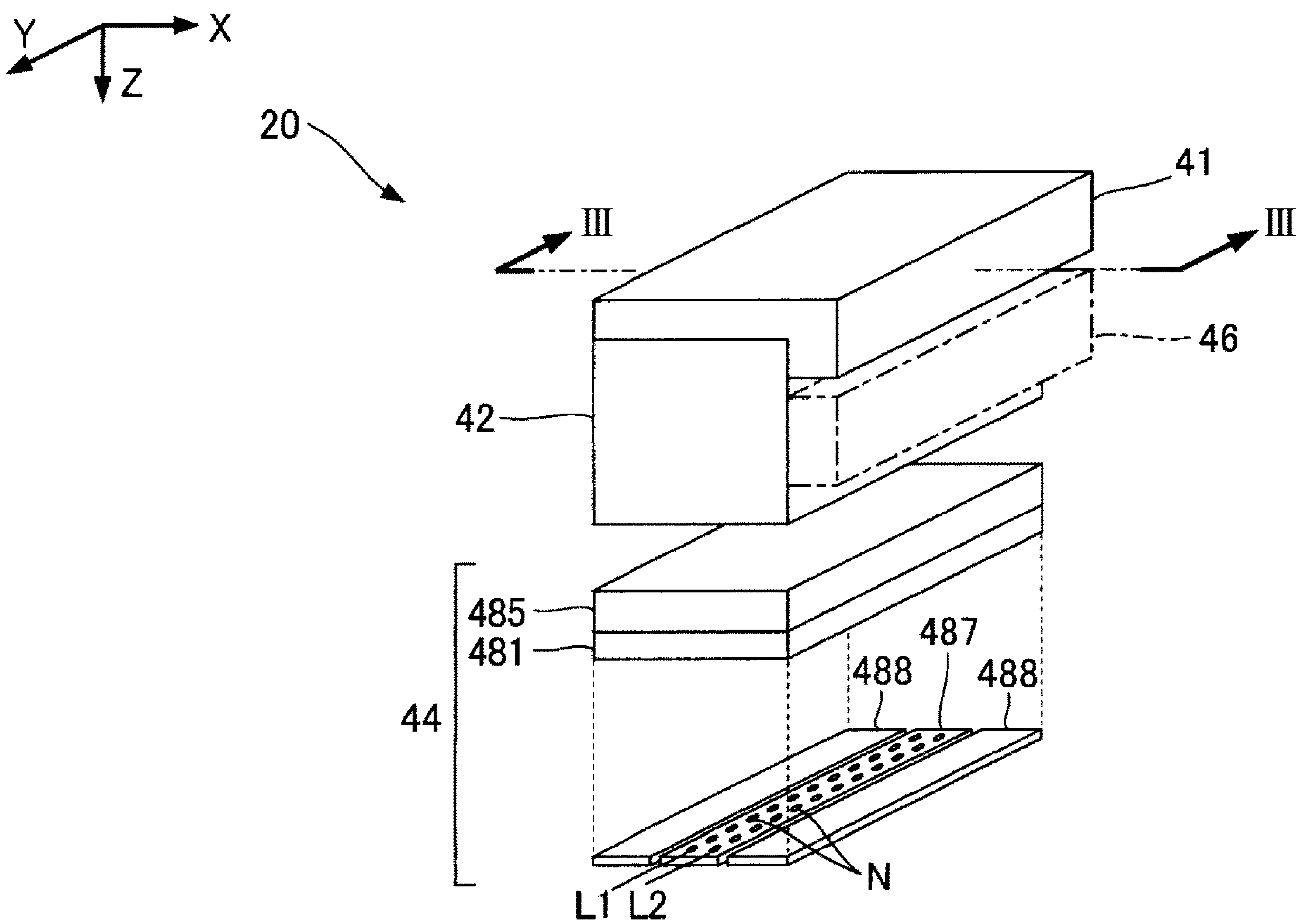


FIG. 2



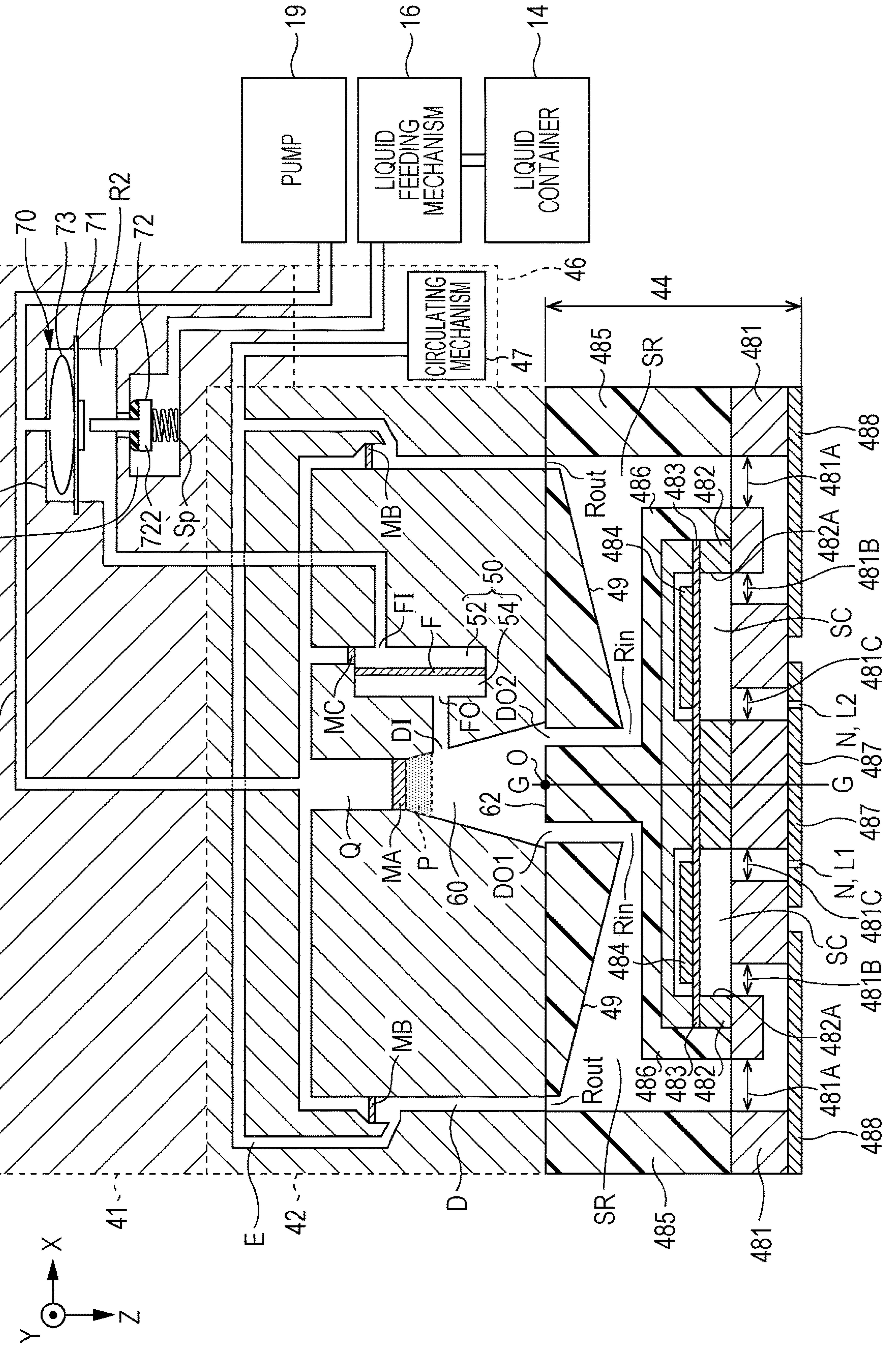

PUMP
LIQUID FEEDING MECHANISM
LIQUID CONTAINER
CIRCULATING MECHANISM

FIG. 3

FIG. 4

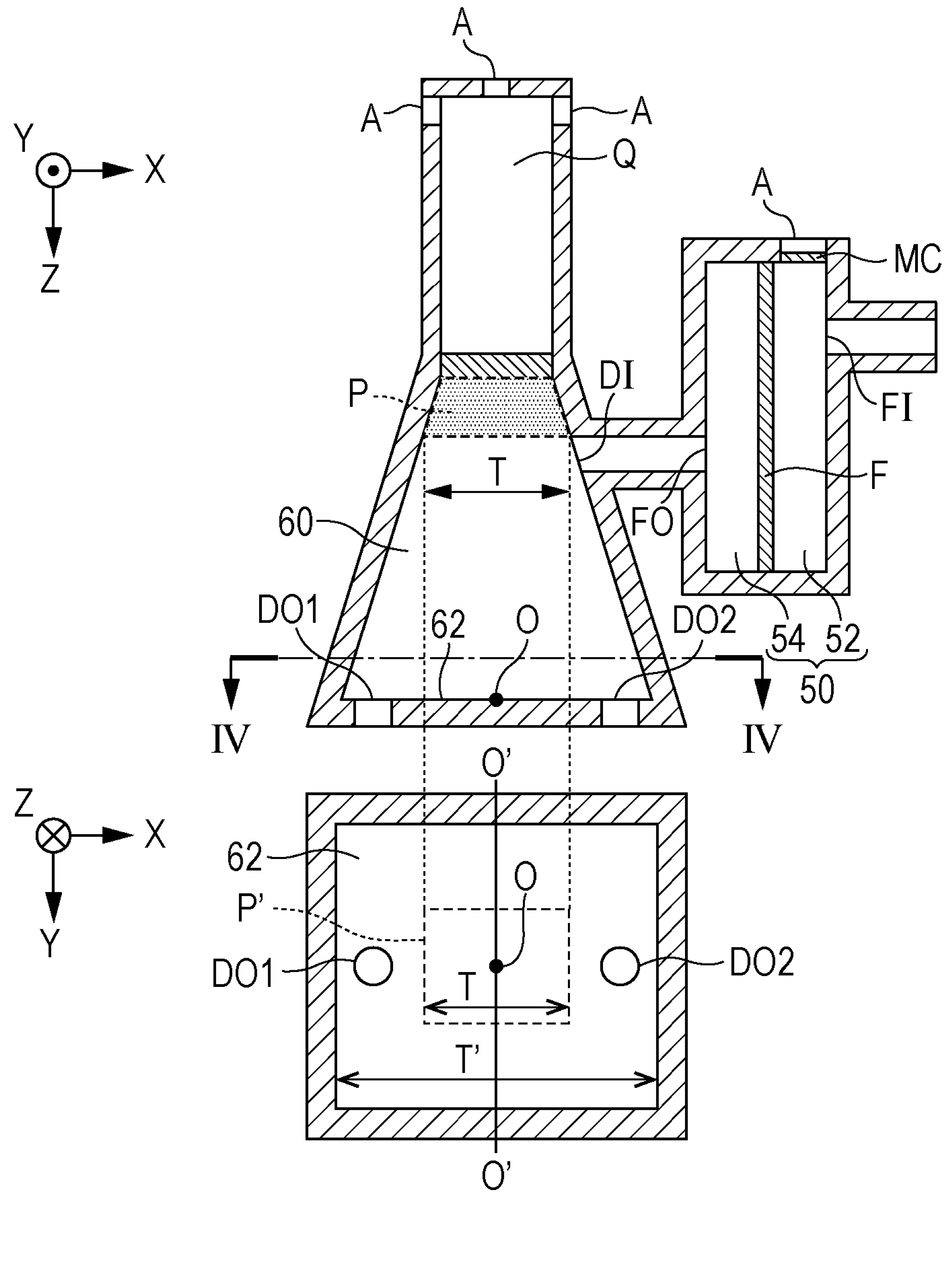

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FIG. 5

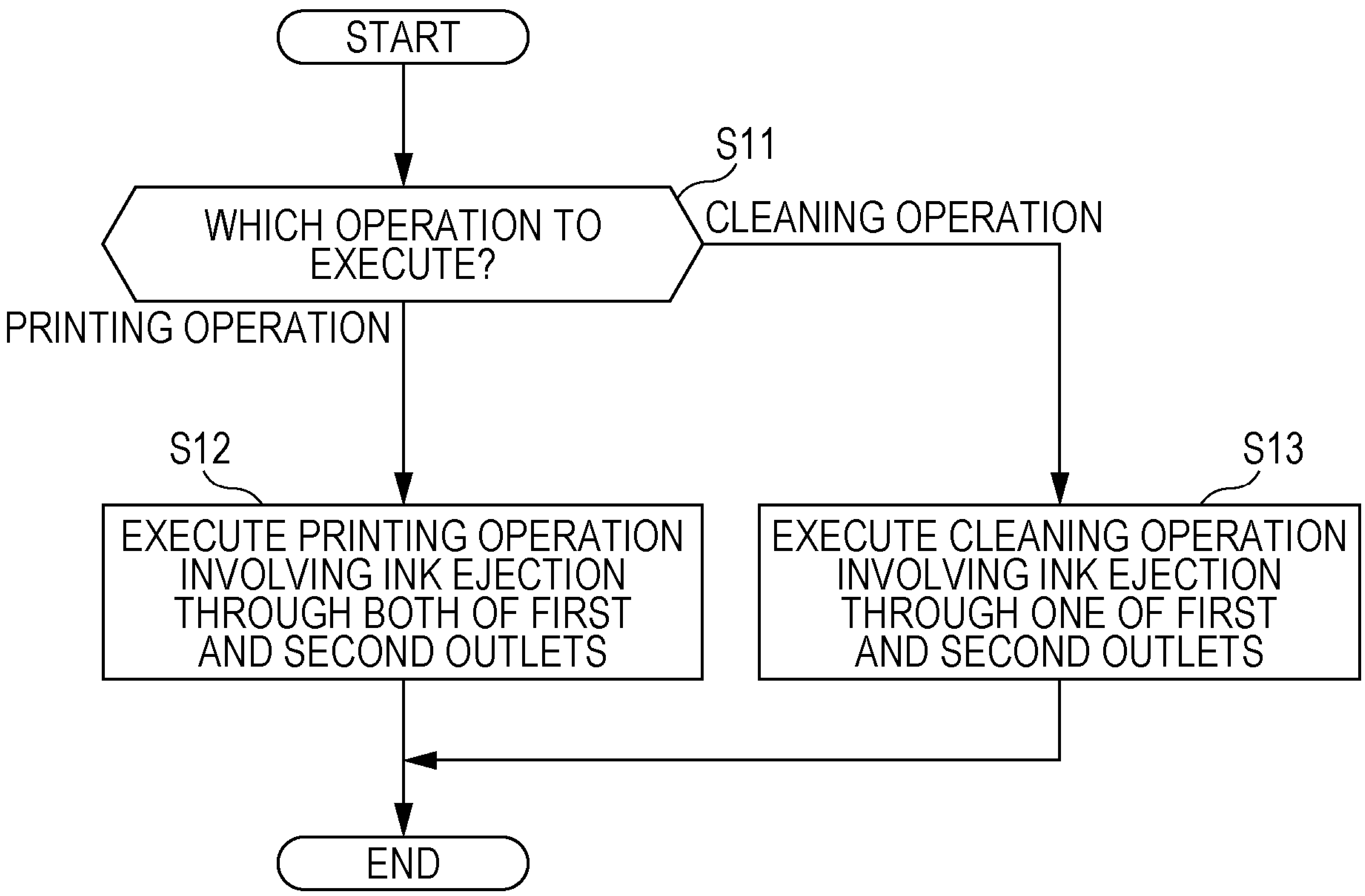
START
S11
WHICH OPERATION TO EXECUTE?
CLEANING OPERATION
PRINTING OPERATION
S12
EXECUTE PRINTING OPERATION INVOLVING INK EJECTION THROUGH BOTH OF FIRST AND SECOND OUTLETS
S13
EXECUTE CLEANING OPERATION INVOLVING INK EJECTION THROUGH ONE OF FIRST AND SECOND OUTLETS
END

FIG. 6

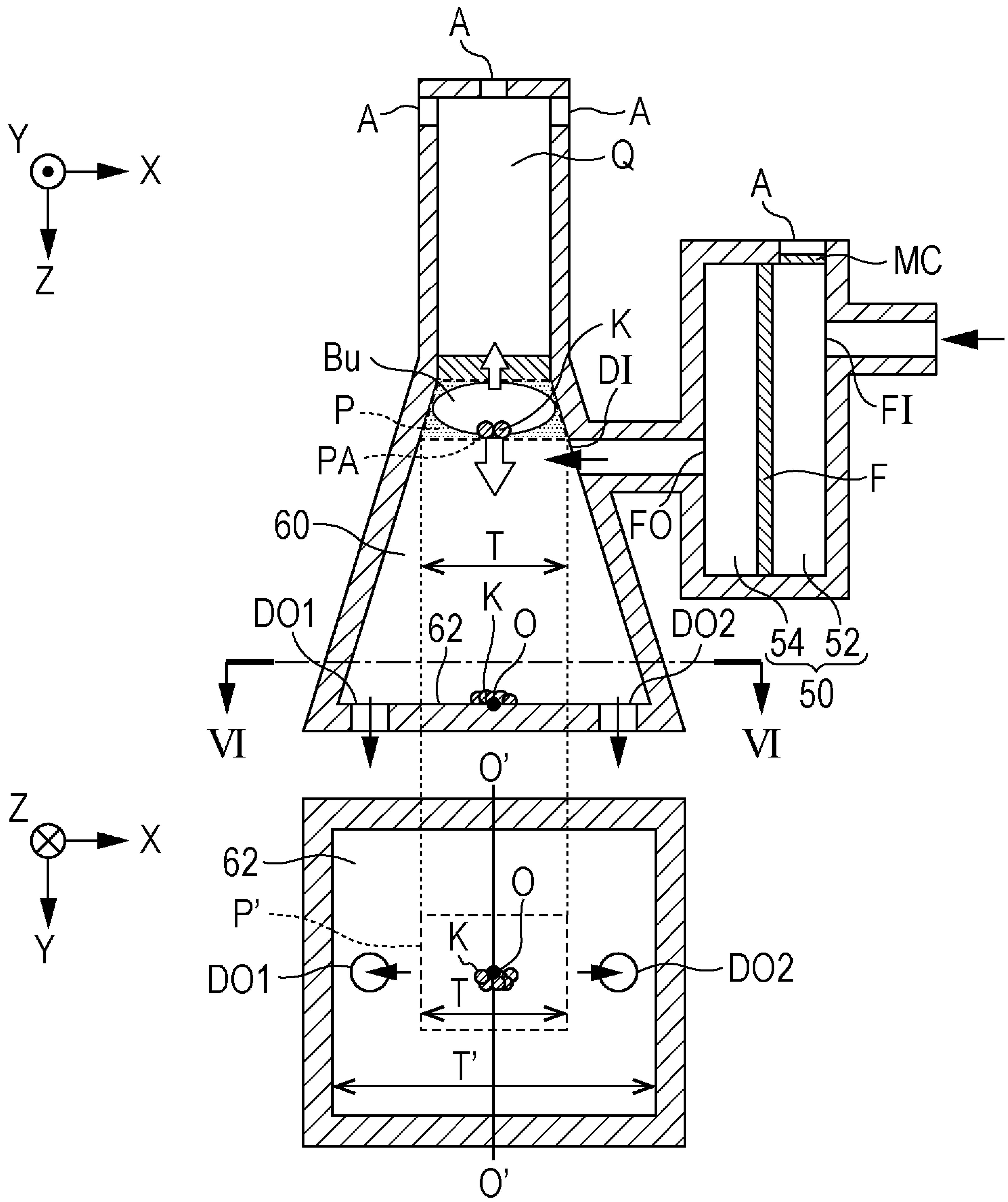

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FIG. 7

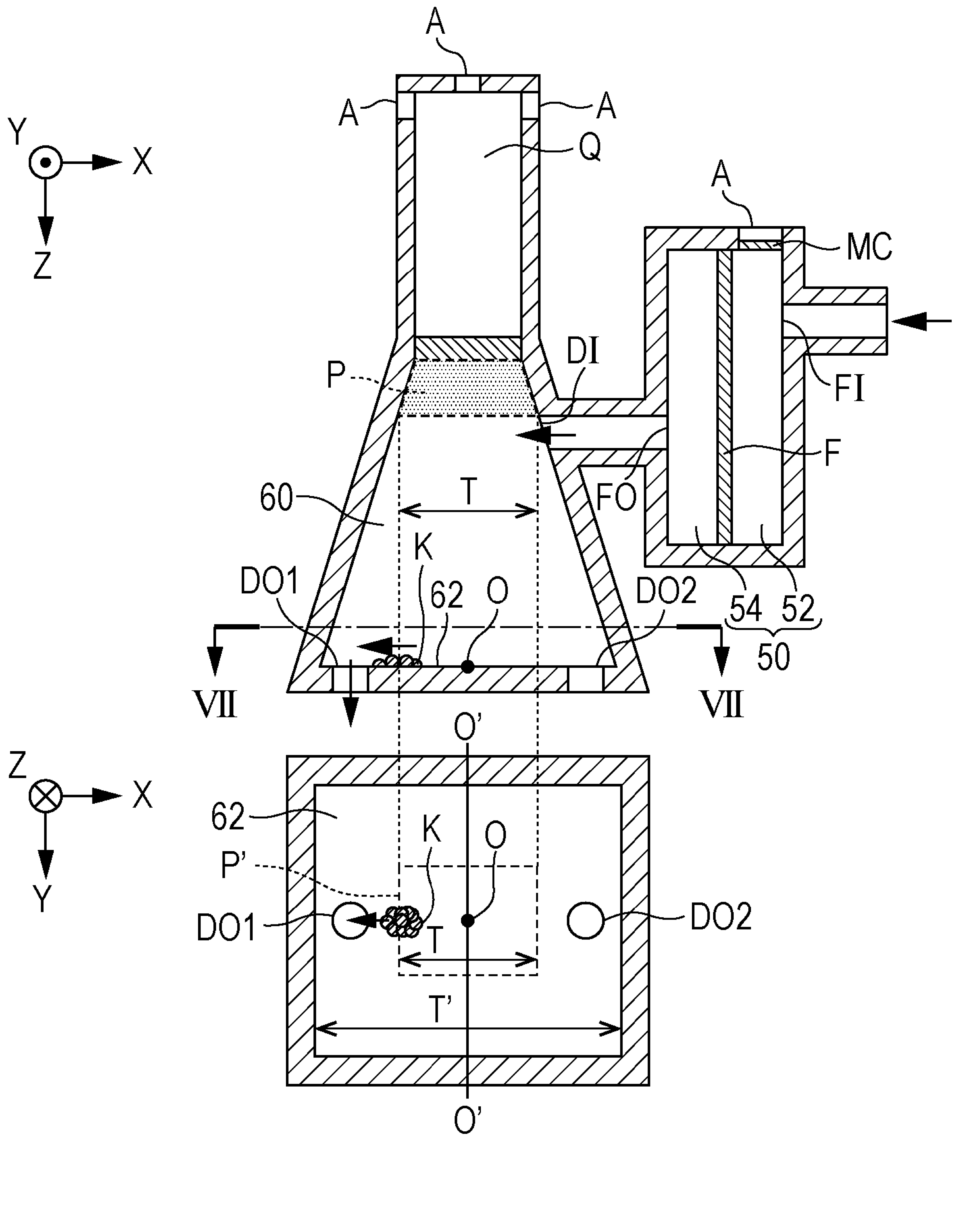

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FIG. 8

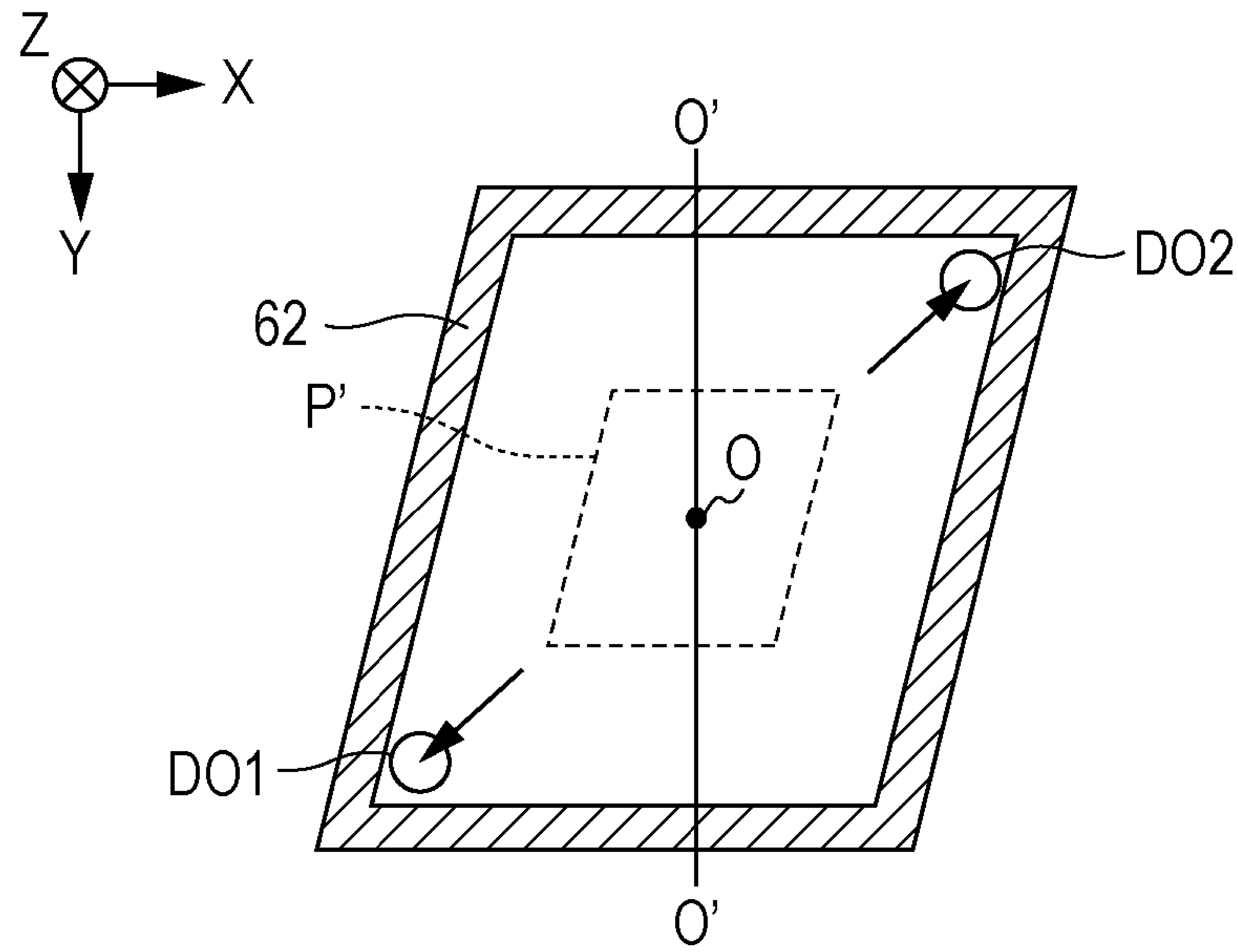

FIG. 9

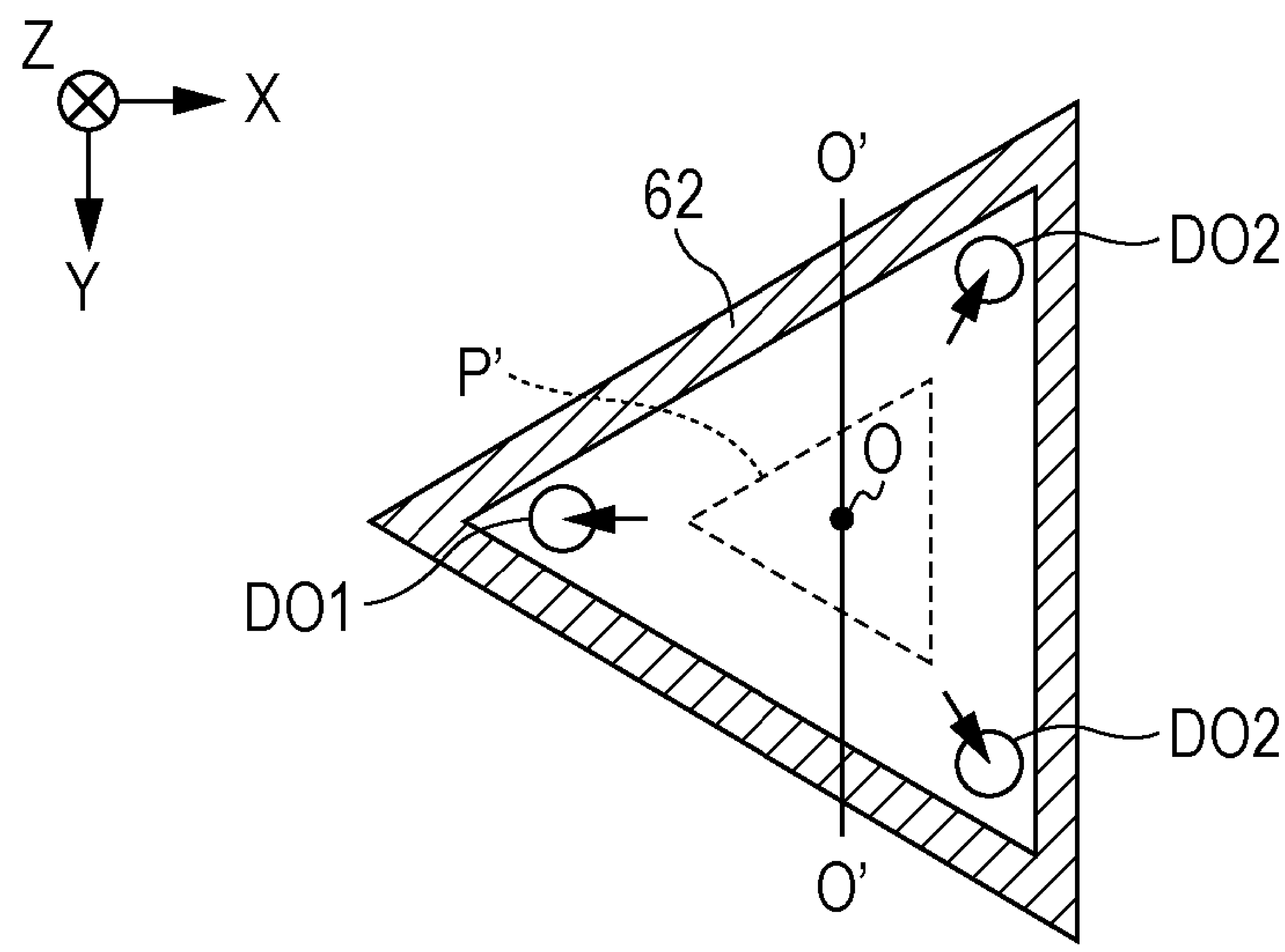

FIG. 10

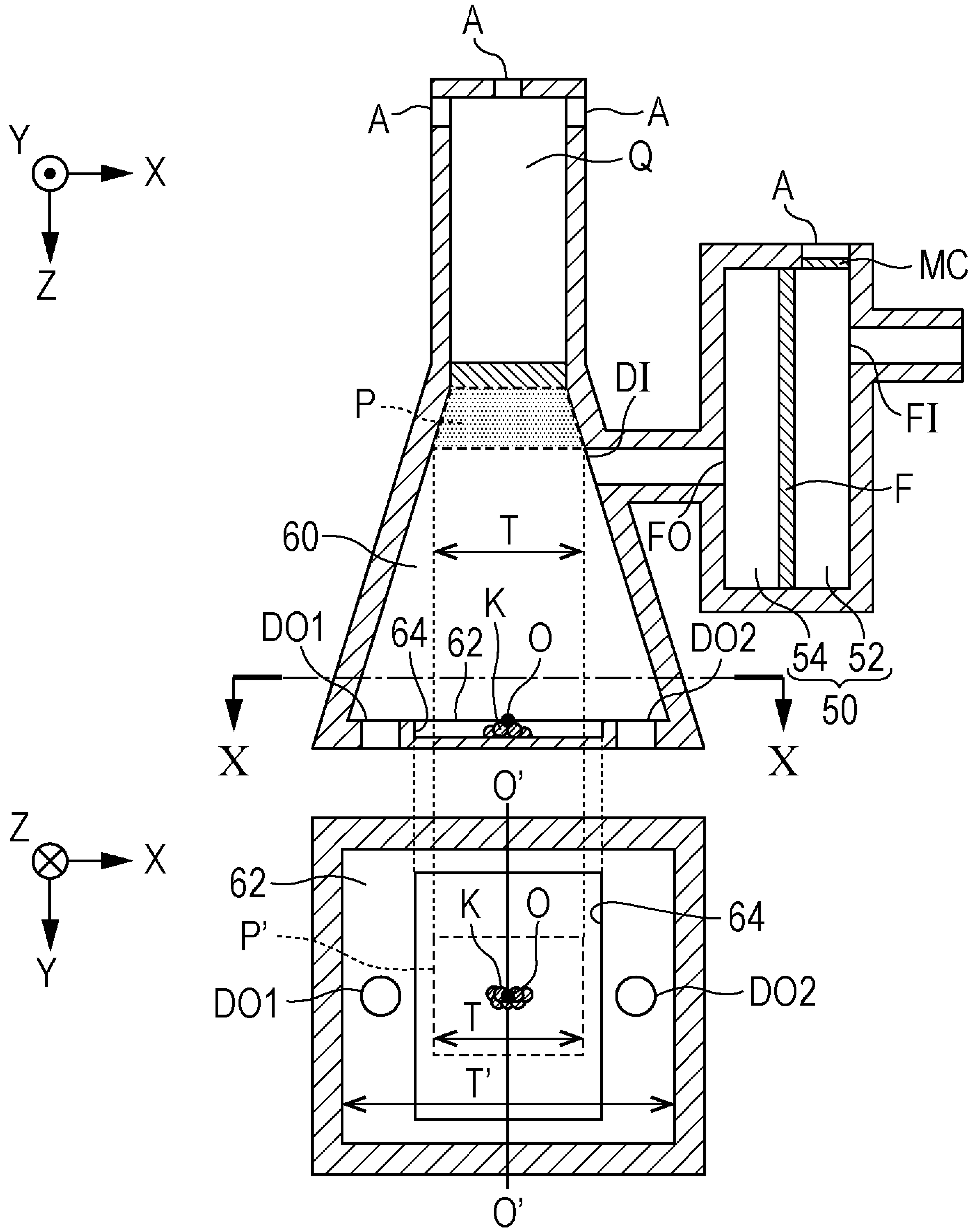

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FIG. 11

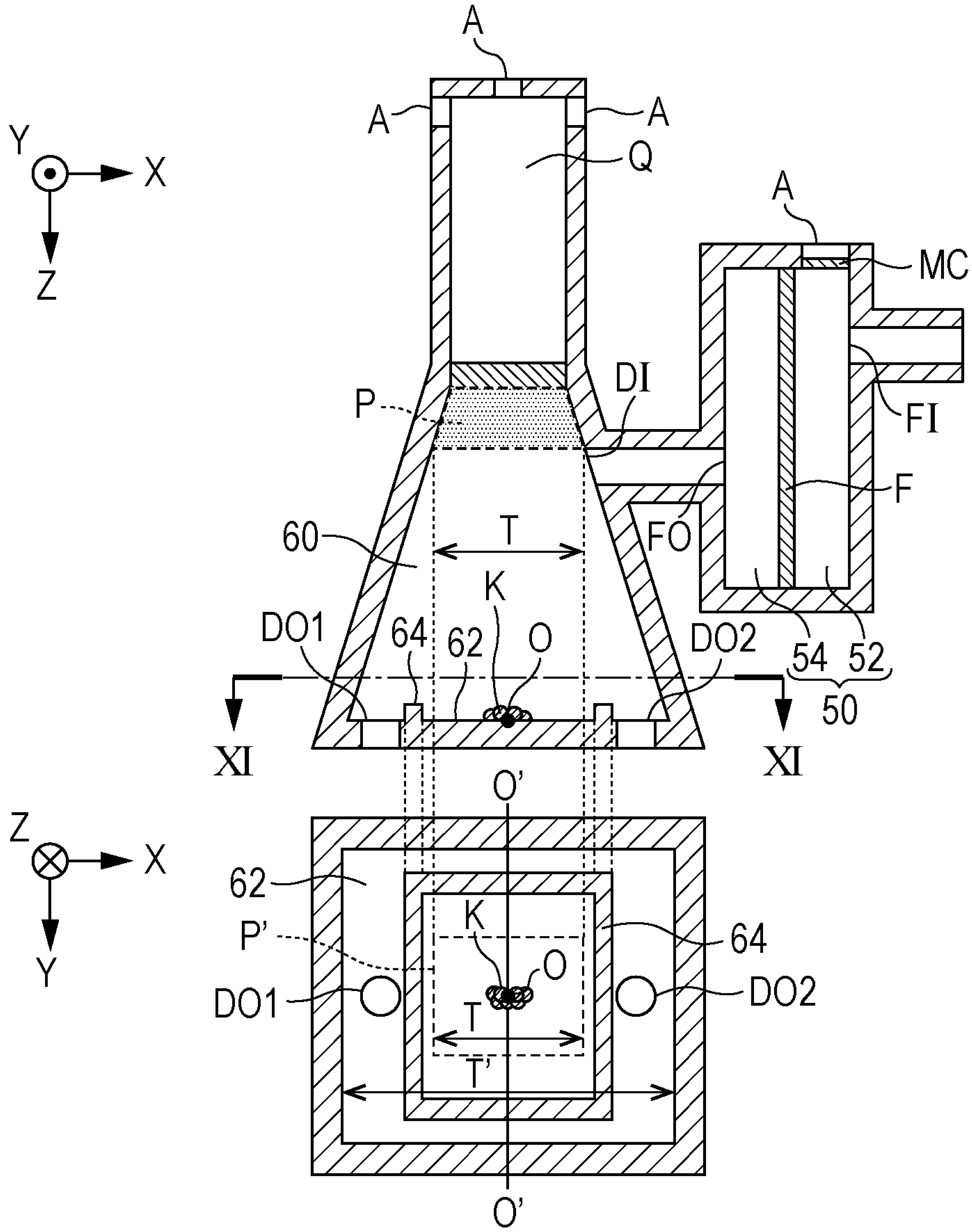
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FIG. 12

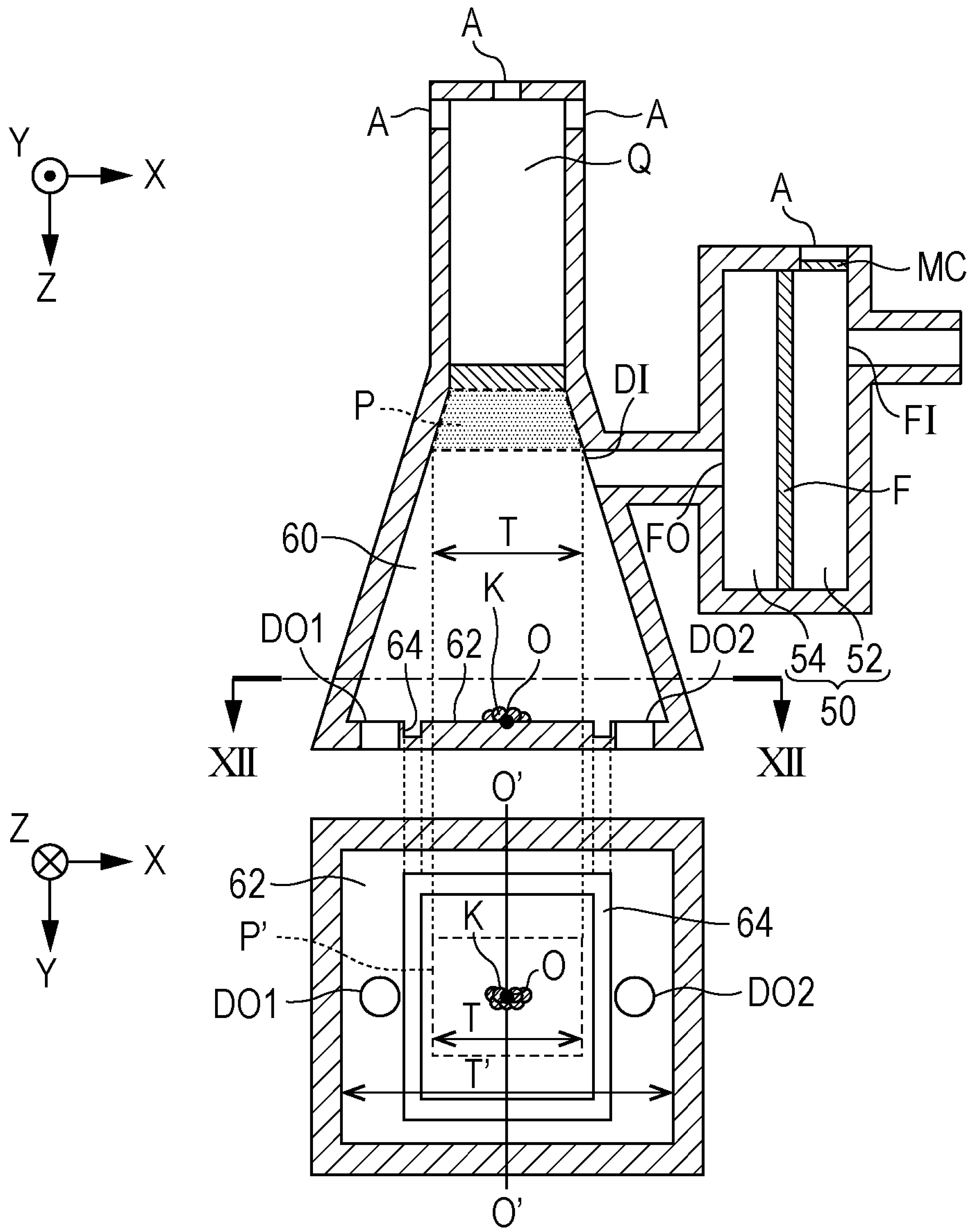

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FIG. 13

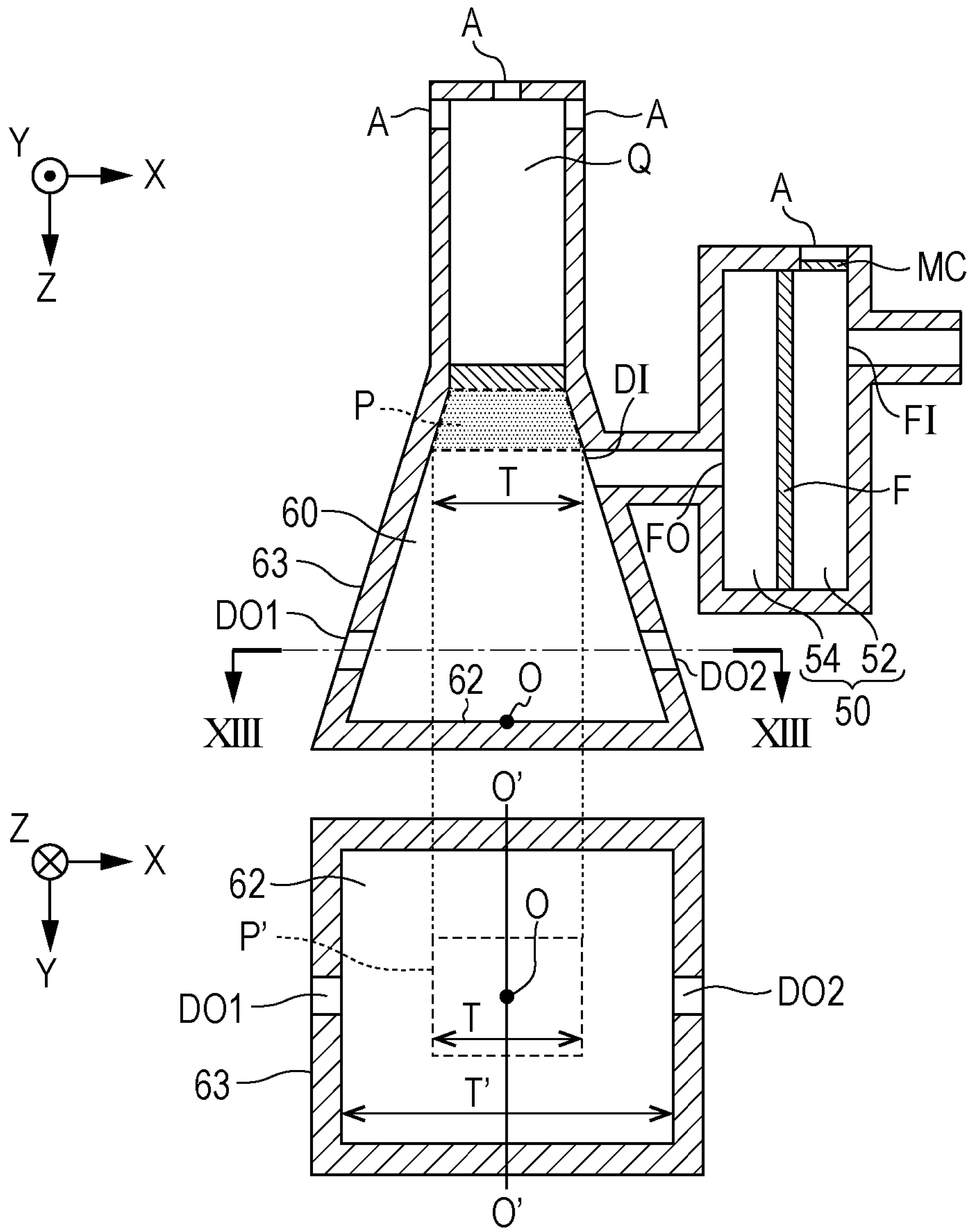
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FIG. 14

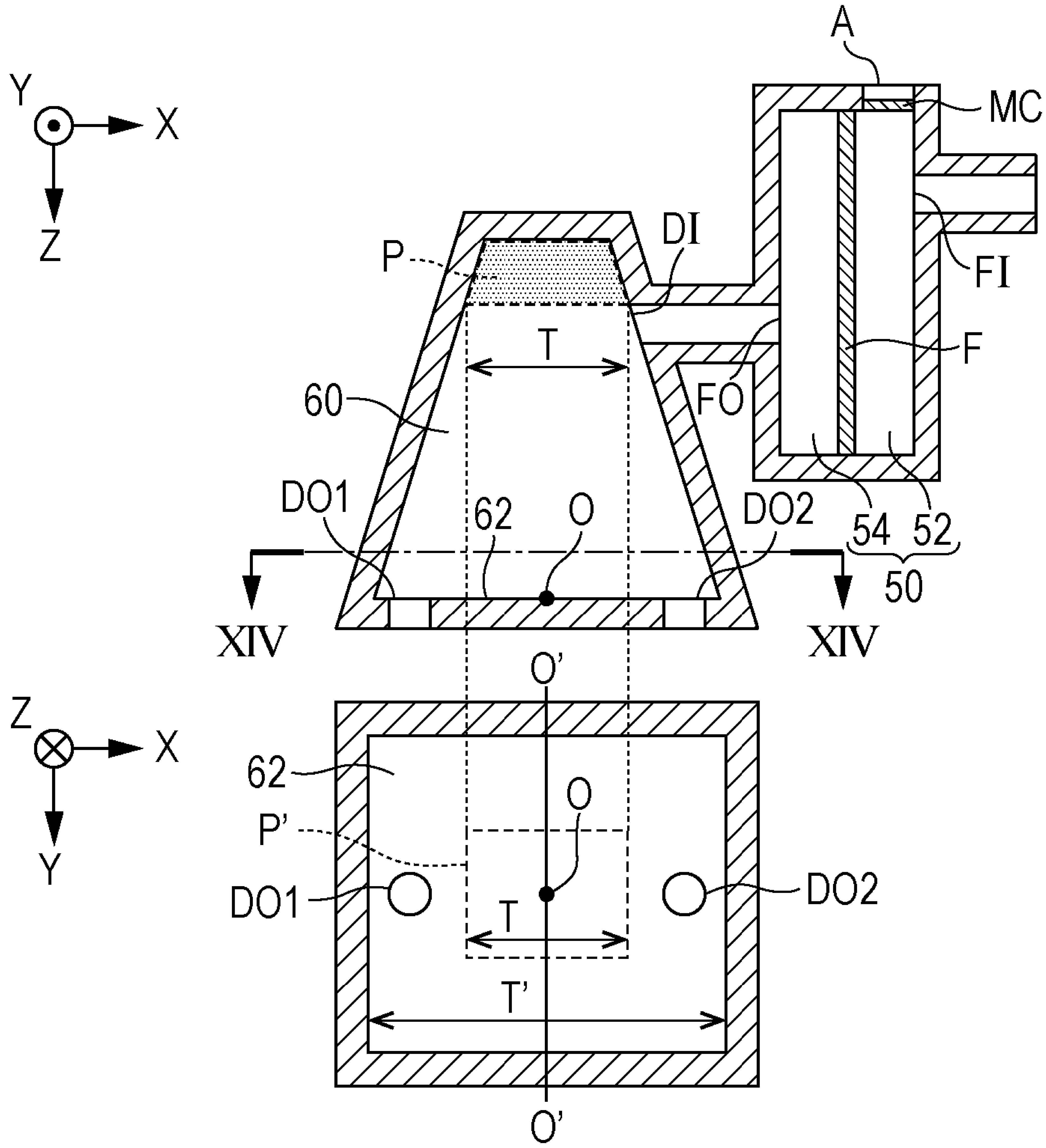
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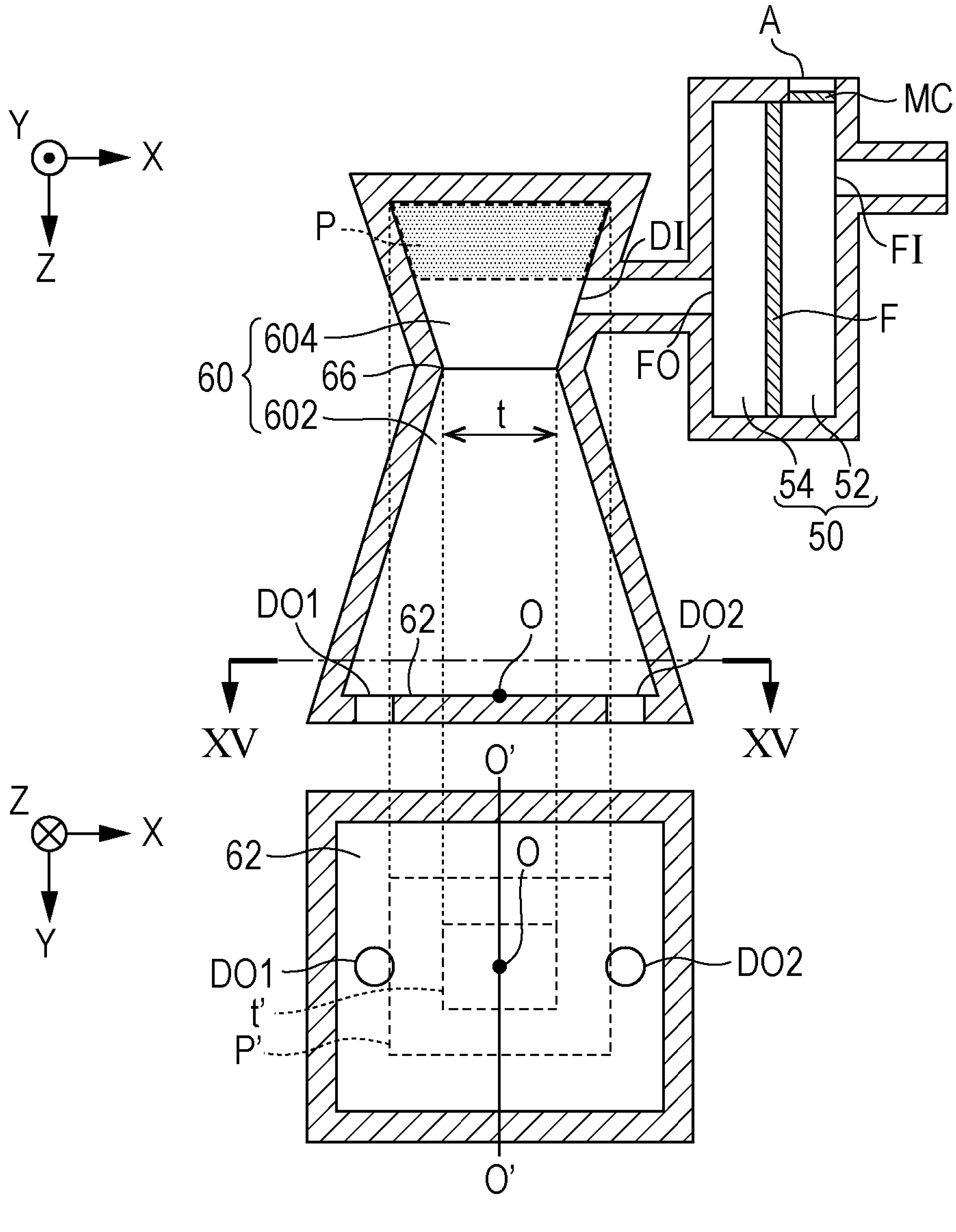
FIG. 15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LIQUID EJECTING APPARATUS AND METHOD OF DRIVING THE SAME

CROSS REFERENCES TO RELATED APPLICATIONS

This application claims priority to Japanese Patent Application No. 2017-166259 filed on Aug. 30, 2017. The entire disclosure of Japanese Patent Application No. 2017-166259 is incorporated herein by reference.

BACKGROUND

1. Technical Field

The present invention relates to a technique of ejecting a liquid, such as ink.

2. Related Art

Some liquid ejecting apparatuses, which include a liquid ejecting head for ejecting a liquid (for example, ink) supplied from a liquid container along a liquid path, are equipped with a filter for removing bubbles that have entered the liquid path and a space for temporarily retaining such bubbles in the middle of the liquid path so as to suppress the bubbles from flowing into the liquid ejecting head. For example, JP-A-2015-231723 discloses an apparatus that includes a filter in the middle of a liquid path and a bubble chamber disposed upstream of the filter. The bubble chamber has a bubble retention space for retaining bubbles that have been successfully captured by the filter.

Undesirably, the bubble retention space in the apparatus disclosed in JP-A-2015-231723 is disposed upstream of the filter and therefore cannot retain bubbles that have passed through the filter. Such bubbles may flow into the liquid ejecting head. To solve this problem, another bubble retention space can be provided downstream of the filter. This space can retain the bubbles that have passed through the filter and thus suppress these bubbles from flowing into the liquid ejecting head and its nozzles. Some types of liquid, however, often generate by-products (solid materials) due to evaporation of the solvent of the liquid at the air-liquid interface where the liquid is in contact with the bubbles retained in the bubble retention space. The by-products generated downstream of the filter cannot be removed by the filter and thus may flow into the liquid ejecting head and its nozzles, resulting in irregular ejection.

SUMMARY

An advantage of some aspects of the invention is to suppress the by-products generated downstream of the filter from flowing into the liquid ejecting head and its nozzles.

A liquid ejecting apparatus according to a first aspect of the invention, which has been proposed to realize the above advantage, includes a filter disposed in a liquid path for supplying liquid to nozzles of a liquid ejecting head, and a liquid storing chamber disposed downstream of the filter in the liquid path. The liquid storing chamber has an inlet through which the liquid enters the liquid storing chamber, a bubble retention space disposed above the inlet in the vertical direction, a bottom disposed below the bubble retention space in the vertical direction, and a first outlet and a second outlet through which the liquid exits the liquid storing chamber. The first outlet is located on one side of an imaginary center line passing through the center of a projected area, which is defined by projecting the bubble retention space onto the bottom in the vertical direction, and the second outlet is located on the other side of the imaginary center line, as viewed in the vertical direction. The liquid storing chamber disposed downstream of the filter can cause the bubbles that have passed through the filter and entered the liquid storing chamber through the inlet to be retained in the bubble retention space. If by-products are generated at the air-liquid interface between the bubbles (gas) and the liquid in the bubble retention space and sink, the configuration can cause such by-products to be accumulated in the projected area on the bottom. In addition, the first outlet and the second outlet are located on both sides of the imaginary center line of the projected area, as viewed in the vertical direction. The liquid exits the liquid storing chamber through the first outlet and the second outlet, thereby generating liquid flows having components in the opposite directions from the imaginary center line of the projected area to the first outlet and the second outlet. The liquid flow components in the opposite directions cancel movements of the by-products accumulated in the projected area and thus suppress the by-products from reaching the first outlet or the second outlet. This configuration can suppress the by-products generated in the bubble retention space downstream of the filter from flowing into the liquid ejecting head and its nozzles through the first outlet or the second outlet.

A liquid ejecting apparatus according to a second aspect of the invention, which has been proposed to realize the above advantage, includes a filter disposed in a liquid path for supplying liquid to nozzles of a liquid ejecting head, and a liquid storing chamber disposed downstream of the filter in the liquid path. The liquid storing chamber has an inlet through which the liquid enters the liquid storing chamber, a bubble retention space disposed above the inlet in the vertical direction, a bottom disposed below the bubble retention space in the vertical direction, and a first outlet and a second outlet through which the liquid exits the liquid storing chamber. The first outlet and the second outlet are located outside a projected area defined by projecting the bubble retention space onto the bottom in the vertical direction, as viewed in the vertical direction. If by-products are generated at the air-liquid interface between the bubbles (gas) and the liquid in the bubble retention space downstream of the filter and sink, the configuration can cause such by-products to be accumulated in the projected area on the bottom. Furthermore, the first outlet and the second outlet are located outside the projected area defined by projecting the bubble retention space onto the bottom in the vertical direction, as viewed in the vertical direction. This configuration can suppress the by-products that have sunk from the bubble retention space from reaching the first outlet or the second outlet. The configuration can thus suppress the by-products generated in the bubble retention space downstream of the filter from flowing into the liquid ejecting head and its nozzles through the first outlet or the second outlet.

It is preferable that the direction from the center of the projected area to the second outlet be opposite to the direction from the center of the projected area to the first outlet, as viewed in the vertical direction. This configuration can facilitate generation of liquid flows in the opposite directions from the center of the projected area to the first outlet and the second outlet, because the direction from the center of the projected area to the second outlet is opposite to the direction from the center of the projected area to the first outlet, as viewed in the vertical direction. The configuration can thus effectively suppress the by-products accumulated in the projected area from approaching the first outlet or the second outlet.

It is preferable that the liquid storing chamber have a section that is orthogonal to the vertical direction, is located below the bubble retention space in the vertical direction, and has an area smaller than the area of the bottom. The projected area of the bubble retention space can have a smaller area than the area of the bottom, because the liquid storing chamber has a section that is orthogonal to the vertical direction, is located below the bubble retention space in the vertical direction, and has a smaller area than the area of the bottom. This configuration can cause the by-products sinking from the bubble retention space to be readily accumulated in the vicinity of the center of the projected area. That is, the configuration can keep the by-products accumulated in the projected area away from the first outlet and the second outlet, thereby suppressing the by-products from flowing out.

It is preferable that the liquid storing chamber have a section that is orthogonal to the vertical direction, is located below the bubble retention space in the vertical direction, and has the smallest area. This configuration can provide a larger section to a bubble retention space than the smallest section, because of the smallest section located below the bubble retention space in the vertical direction. In addition, regardless of the larger bubble retention space, the configuration can cause the by-products sinking from the bubble retention space to be accumulated in the area defined by projecting the smallest section onto the bottom, which is smaller than the projected area of the bubble retention space. That is, the configuration can keep the by-products accumulated in the projected area away from the first outlet and the second outlet, thereby suppressing the by-products from flowing out.

It is preferable that the bottom be provided with a restricting portion that is disposed at least between the first outlet and the projected area and between the second outlet and the projected area, as viewed in the vertical direction, and that restricts movement of by-products accumulated on the bottom. This configuration can suppress the by-products from approaching the first outlet and the second outlet across the restricting portion regardless of the occurrence of a liquid flow on the bottom that brings the by-products, because of the restricting portion on the bottom that is disposed at least between the first outlet and the projected area and between the second outlet and the projected area, as viewed in the vertical direction, and that restricts movement of the by-products accumulated on the bottom. The configuration can thus more effectively suppress the by-products from flowing into the liquid ejecting head and its nozzles, compared with the configuration without a restricting portion.

It is preferable that the first outlet and the second outlet be located below the inlet in the vertical direction. This configuration, including the first outlet and the second outlet located below the inlet in the vertical direction, can provide a larger bubble retention space, compared with the configuration including the first outlet and the second outlet located above the inlet.

It is preferable that the first outlet and the second outlet be located below the center of the liquid storing chamber in the vertical direction. This configuration, including the first outlet and the second outlet located below the center of the liquid storing chamber in the vertical direction, can provide a larger bubble retention space and more readily guide bubbles into the bubble retention space using buoyancy, compared with the configuration including the first outlet and the second outlet located above the center of the liquid storing chamber.

It is preferable that the liquid ejecting apparatus further include a degassing chamber that is disposed above the bubble retention space in the vertical direction and that degases the liquid with a gas permeable film. This configuration can cause the bubbles retained in the bubble retention space to be discharged to the degassing chamber, because of the degassing chamber that is disposed above the bubble retention space in the vertical direction and that degases the liquid with the gas permeable film. The configuration can thus reduce the generation of by-products at the air-liquid interface between the bubbles and the liquid in the bubble retention space.

It is preferable that the liquid be caused to exit the liquid storing chamber through one of the first outlet and the second outlet so as to generate a flow of the liquid on the bottom. This configuration can cause the by-products accumulated on the bottom to be discharged through one of the first outlet and the second outlet with the flow of the liquid.

A method of driving a liquid ejecting apparatus according to a third aspect, which has been proposed to realize the above advantage, is directed at a liquid ejecting apparatus including a filter disposed in a liquid path for supplying liquid to nozzles of a liquid ejecting head, and a liquid storing chamber disposed downstream of the filter in the liquid path. The liquid storing chamber has an inlet through which the liquid enters the liquid storing chamber, a bubble retention space disposed above the inlet in the vertical direction, a bottom disposed below the bubble retention space in the vertical direction, and a first outlet and a second outlet through which the liquid exits the liquid storing chamber. The first outlet is located on one side of an imaginary center line passing through the center of a projected area, which is defined by projecting the bubble retention space onto the bottom in the vertical direction, and the second outlet is located on the other side of the imaginary center line, as viewed in the vertical direction. The method involves causing the liquid to exit the liquid storing chamber through the first outlet and the second outlet. The liquid storing chamber disposed downstream of the filter can cause the bubbles that have passed through the filter and entered the liquid storing chamber through the inlet to be retained in the bubble retention space. If by-products are generated at the air-liquid interface between the bubbles and the liquid in the bubble retention space and sink, the configuration can cause such by-products to be accumulated in the projected area on the bottom. In addition, the liquid exits the liquid storing chamber through the first outlet and the second outlet disposed on both sides of the imaginary center line of the projected area, as viewed in the vertical direction, thereby generating liquid flows having components in the opposite directions from the imaginary center line of the projected area to the first outlet and the second outlet. The liquid flow components in the opposite directions cancel movements of the by-products accumulated in the projected area and thus suppress the by-products from reaching the first outlet or the second outlet. This configuration can thus suppress the by-products generated in the bubble retention space downstream of the filter from flowing into the liquid ejecting head and its nozzles through the first outlet or the second outlet.

It is preferable that the liquid ejecting apparatus further include a degassing chamber that is disposed above the bubble retention space in the vertical direction and that degases the liquid with a gas permeable film, and that the method further involve discharging bubbles retained in the bubble retention space to the degassing chamber. This configuration can cause the bubbles retained in the bubble retention space to be discharged to the degassing chamber and can thus reduce the generation of by-products at the air-liquid interface between the bubbles and the liquid in the bubble retention space.

It is preferable that the method further involve causing the liquid to exit the liquid storing chamber through one of the first outlet and the second outlet and generating a flow of the liquid on the bottom. This configuration can cause the by-products accumulated on the bottom to be discharged through one of the first outlet and the second outlet with the flow of the liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described with reference to the accompanying drawings, wherein like numbers reference like elements.

FIG. **1** illustrates a liquid ejecting apparatus according to a first embodiment.

FIG. **2** is an exploded perspective view of a head unit.

FIG. **3** is a sectional view of the head unit taken along line III-III in FIG. **2**.

FIG. **4** illustrates sections of a filter chamber and a liquid storing chamber.

FIG. **5** is a flowchart illustrating a method of driving the liquid ejecting apparatus.

FIG. **6** illustrates a process in the liquid storing chamber during a printing operation.

FIG. **7** illustrates a process in the liquid storing chamber during a cleaning operation.

FIG. **8** is a sectional view for illustrating the bottom of a liquid storing chamber according to a first modification of the first embodiment.

FIG. **9** is a sectional view for illustrating the bottom of a liquid storing chamber according to a second modification of the first embodiment.

FIG. **10** illustrates sections of a liquid storing chamber according to a second embodiment.

FIG. **11** illustrates sections of a liquid storing chamber according to a first modification of the second embodiment.

FIG. **12** illustrates sections of a liquid storing chamber according to a second modification of the second embodiment.

FIG. **13** illustrates sections of a liquid storing chamber according to a third embodiment.

FIG. **14** illustrates sections of a liquid storing chamber according to a fourth embodiment.

FIG. **15** illustrates sections of a liquid storing chamber according to a modification of the fourth embodiment.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

First Embodiment

FIG. **1** illustrates a partial configuration of a liquid ejecting apparatus **10** according to a first embodiment of the invention. The liquid ejecting apparatus **10** according to the first embodiment is an ink jet printer that ejects ink (an exemplary liquid) onto a medium **11**, such as a print sheet. The liquid ejecting apparatus **10** illustrated in FIG. **1** includes a controller **12**, a transport mechanism **15**, a carriage **18**, and a head unit **20**. The liquid ejecting apparatus **10** is provided with a liquid container **14** that stores ink.

The liquid container **14** is an ink tank cartridge having a box shape and is detachably attached to the body of the liquid ejecting apparatus **10**. The liquid container **14** may also be an ink pack cartridge having a pouch shape other than the box shape. The liquid container **14** stores ink. The ink may be black ink or color ink. The ink stored in the liquid container **14** is pumped to the head unit **20**.

The controller **12** comprehensively controls all components of the liquid ejecting apparatus **10**. The transport mechanism **15** transports the medium **11** in the Y direction under the control of the controller **12**. The head unit **20** ejects ink supplied from the liquid container **14** onto the medium **11** from individual nozzles N under the control of the controller **12**.

The head unit **20** is mounted on the carriage **18**. Although FIG. **1** illustrates a single head unit **20** mounted on the carriage **18**, this configuration should not be construed as limiting the invention. Two or more head units **20** may also be mounted on the carriage **18**. The controller **12** causes the carriage **18** to reciprocate in the X direction, which intersects the Y direction and which, in FIG. **1**, is orthogonal to the Y direction. The head unit **20** ejects ink onto the medium **11** in parallel with the transport of the medium **11** and with the reciprocation of the carriage **18** to form a desired image on the surface of the medium **11**. Alternatively, two or more head units **20** may be mounted on the carriage **18**. It should be noted that the direction orthogonal to the XY plane (parallel to the surface of the medium **11**) is defined as the Z direction.

FIG. **2** is an exploded perspective view of the head unit **20**. FIG. **3** is a sectional view of the head unit **20** taken along line III-III in FIG. **2**. With reference to FIGS. **2** and **3**, the head unit **20** includes a valve mechanism unit **41**, a channel unit **42**, a liquid ejecting head **44**, and a channel component **46**. The liquid ejecting head **44** ejects ink from the nozzles N. The channel unit **42** includes a liquid path D for supplying ink from the valve mechanism unit **41** to the liquid ejecting head **44**. The liquid ejecting head **44** ejects ink, which is supplied from the liquid container **14** through the channel component **46** and the channel unit **42**, onto the medium **11**. The valve mechanism unit **41** includes an on-off valve **72** (described below) for controlling the opening and closing of the liquid path D for ink supplied from the channel component **46**. The valve mechanism unit **41** is provided on the channel unit **42** such that a part of the valve mechanism unit **41** protrudes from a side surface of the channel unit **42** in the X direction. The channel component **46** faces this surface of the channel unit **42**. The top surface of the channel component **46** and the bottom surface of the valve mechanism unit **41** face each other while being spaced from each other in the Z direction. The liquid path D inside the channel component **46** is in communication with the liquid path D inside the valve mechanism unit **41**.

The liquid ejecting head **44** includes a channel defining substrate **481**. The liquid ejecting head **44** further includes a pressure chamber defining substrate **482**, a diaphragm **483**, piezoelectric elements **484**, a housing **485**, and a sealing plate **486** on one side of the channel defining substrate **481**. The liquid ejecting head **44** further includes a nozzle plate **487** and buffer plates **488** on the other side of the channel defining substrate **481**. Each of the channel defining substrate **481**, the pressure chamber defining substrate **482**, and the nozzle plate **487** is composed of a silicon plate, for example. The housing **485** is fabricated by injection molding of a resin material, for example. The nozzles N are provided in the nozzle plate **487**. The surface of the nozzle plate **487** on the opposite side of the channel defining substrate **481** corresponds to an ejection surface (the surface of the liquid ejecting head **44** that faces the medium **11**).

The nozzles N are divided into a first nozzle array L**1** and a second nozzle array L**2**. Each of the first nozzle array L**1** and the second nozzle array L**2** is a group of nozzles N arranged in the Y direction. The first nozzle array L**1** and the second nozzle array L**2** are spaced from each other in the X direction. The positions of the individual nozzles N of the first nozzle array L**1** may be displaced from the positions of the corresponding nozzles N of the second nozzle array L**2** in the Y direction (to achieve a zigzag or staggered arrangement).

With reference to FIG. **3**, the liquid ejecting head **44** according to the embodiment has a structure associated with the first nozzle array L**1** (the left-hand side of FIG. **3**) and a structure associated with the second nozzle array L**2** (the right-hand side of FIG. **3**), which are substantially symmetrical to each other about an imaginary line G-G extending in the Z direction and which are substantially identical to each other. Accordingly, the following description focuses mainly on the structure associated with the first nozzle array L**1** (the left side of the imaginary line G-G in FIG. **3**).

The channel defining substrate **481** has an opening **481**A, branch channels **481**B, and communication channels **481**C. The branch channels **481**B and the communication channels **481**C are through holes corresponding to the individual nozzles N. The opening **481**A is continuous across the array of the nozzles N. The buffer plate **488** is a compliance substrate provided to the surface of the channel defining substrate **481** on the opposite side of the pressure chamber defining substrate **482** and covers the opening **481**A. The pressure fluctuation in the opening **481**A is absorbed by the buffer plates **488**.

The housing **485** includes a common liquid chamber (reservoir) SR in communication with the opening **481**A of the channel defining substrate **481**. The common liquid chamber SR on the left-hand side of FIG. **3** is a space for storing ink to be supplied to the nozzles N of the first nozzle array L**1** and is continuous across these nozzles N. In contrast, the common liquid chamber SR on the right-hand side of FIG. **3** is a space for storing ink to be supplied to the nozzles N of the second nozzle array L**2** and is continuous across these nozzles N. Each of the common liquid chambers SR has an inlet Rin into which ink flows from the upstream side.

The pressure chamber defining substrate **482** has openings **482**A corresponding to the individual nozzles N. The diaphragm **483** is a plate capable of elastic deformation and is disposed on the surface of the pressure chamber defining substrate **482** on the opposite side of the channel defining substrate **481**. The space inside each opening **482**A of the pressure chamber defining substrate **482** defined between the diaphragm **483** and the channel defining substrate **481** functions as a pressure chamber (cavity) SC. The ink supplied from the common liquid chamber SR through the corresponding branch channel **481**B is charged into the pressure chamber SC. Each of the pressure chambers SC is in communication with the corresponding nozzle N through the communication channel **481**C of the channel defining substrate **481**.

The piezoelectric elements **484** are disposed on the surface of the diaphragm **483** on the opposite side of the pressure chamber defining substrate **482** so as to correspond to the individual nozzles N. Each of the piezoelectric elements **484** is a driving element composed of mutually opposed electrodes holding a piezoelectric body therebetween. If the piezoelectric element **484** deforms in response to supply of a driving signal, the diaphragm **483** oscillates. This oscillation varies the pressure in the pressure chamber SC and causes the ink in the pressure chamber SC to be ejected from the nozzle N. The sealing plate **486** protects the piezoelectric elements **484**. The piezoelectric elements **484** are connected to the controller **12** via, for example, a flexible printed circuit (FPC) or a chip-on-film (COF) (which are not shown).

The valve mechanism unit **41** and the channel unit **42** function as a channel structure including the liquid path D and an air path A. The valve mechanism unit **41** includes a valve mechanism **70** (self-sealing valve). The channel unit **42** includes a filter chamber **50** and a liquid storing chamber **60**. The liquid path D is used to supply ink from the liquid container **14** to the nozzles N of the liquid ejecting head **44**. The valve mechanism **70**, the filter chamber **50**, and the liquid storing chamber **60** are provided in the order mentioned from the upstream side to the downstream side of the liquid path D. The liquid ejecting head **44** is disposed downstream of the liquid storing chamber **60**. The air path A is in communication with a compression chamber RC for controlling the valve mechanism **70** of the liquid path D and in communication with a degassing chamber Q for degassing the ink (removing bubbles from ink) in the liquid path D with gas permeable films MA, MB, and MC.

The valve mechanism **70** includes an upstream path R**1**, a downstream path R**2**, and the compression chamber RC that constitute a part of the liquid path D. The upstream path R**1** is connected to a liquid feeding mechanism **16** through the channel component **46**. The liquid feeding mechanism **16** supplies (that is, pumps) ink stored in the liquid container **14** to the head unit **20** in a compressed state. The on-off valve **72** is disposed between the upstream path R**1** and the downstream path R**2**. The downstream path R**2** and the compression chamber RC hold a flexible film **71** therebetween.

The on-off valve **72** opens or closes the liquid path D for supplying ink to the liquid ejecting head **44**. The on-off valve **72** has a valve body **722**. The valve body **722** is disposed between the upstream path R**1** and the downstream path R**2** and connects or disconnects the upstream path R**1** to or from the downstream path R**2** (switches between an open state and a closed state). The valve body **722** is equipped with a spring Sp that urges the valve body **722** in the direction for disconnecting the upstream path R**1** from the downstream path R**2**. That is, if no force is applied to the valve body **722**, the upstream path R**1** is disconnected from the downstream path R**2**. In contrast, if a certain force shifts the valve body **722** in the positive Z direction against the urging force of the spring Sp, the upstream path R**1** is connected to the downstream path R**2**.

The compression chamber RC is provided with a pouch body **73**. The pouch body **73** is a bag composed of an elastic material, such as rubber. The pouch body **73** expands in response to compression in the air path A and contracts in response to decompression in the air path A. The pouch body **73** is connected to a pump **19** through the air path A in the channel component **46**. The pump **19** according to the embodiment is capable of compression and decompression in the air path A and is typically a pneumatic pump. The pump **19** may be a single pump capable of both compression and decompression or may be realized as separate pumps each respectively dedicated to compression or decompression. The pump **19** is driven by a sequence selected from multiple sequences in accordance with an instruction from the controller **12**. The multiple sequences contain a compression sequence for supplying air to the air path A and a decompression sequence for evacuating air from the air path A. The compression (air supply) in the air path A in response to the compression sequence expands the pouch body **73**, while the decompression (air evacuation) in the air path A in response to the decompression sequence contracts the pouch body **73**.

While the pouch body **73** is in a contracted state within a certain range of pressure in the downstream path R**2**, the valve body **722** is urged upward (in the negative Z direction) by the spring Sp, thereby disconnecting the upstream path R**1** from the downstream path R**2**. In contrast, if the pressure in the downstream path R**2** falls below a certain threshold due to ejection of ink by the liquid ejecting head **44** or air evacuation from the outside, the valve body **722** shifts downward (in the positive Z direction) against the urging force of the spring Sp, thereby connecting the upstream path R**1** to the downstream path R**2**. If the pouch body **73** expands in response to compression with the pump **19**, the pouch body **73** pushes the flexible film **71** and the valve body **722** downward against the urging force of the spring Sp, thereby shifting the valve body **722** in the positive Z direction. The pushing of the flexible film **71** shifts the valve body **722** and thus opens the on-off valve **72**. That is, the compression with the pump **19** can forcibly open the on-off valve **72** regardless of the pressure in the downstream path R**2**. Exemplary cases of pushing the flexible film **71** by compression with the pump **19** and forcibly opening the on-off valve **72** include a case of charging ink (hereinafter referred to as "initial charging") into the head unit **20** at the initial setting and a case of discharging ink from the nozzles N during a cleaning operation.

The filter chamber **50** is equipped with a filter F. The filter F is disposed so as to intersect the liquid path D leading to the liquid ejecting head **44** and captures bubbles and by-products contained in ink. Specifically, the filter F functions as a compartment between a space **52** and a space **54**. The space **52** on the upstream side is in communication with the downstream path R**2** of the valve mechanism unit **41** through an inlet FI, while the space **54** on the downstream side is in communication with the liquid storing chamber **60** through an outlet FO.

The liquid storing chamber **60** is a space for temporarily storing ink. The liquid storing chamber **60** has an inlet DI into which the ink that has passed through the filter F flows from the space **54** through the outlet FO, and outlets (a first outlet DO**1** and a second outlet DO**2**) from which the ink flows to the nozzles N. The liquid storing chamber **60** according to the embodiment has two outlets including the first outlet DO**1** in communication with the nozzles N of the first nozzle array L**1** and the second outlet DO**2** in communication with the nozzles N of the second nozzle array L**2**. Alternatively, the liquid storing chamber **60** may include two or more first outlets DO**1** and two or more second outlets DO**2**. The first outlet DO**1** and the second outlet DO**2** are disposed below the inlet DI in the vertical direction (the Z direction). The first outlet DO**1** and the second outlet DO**2** have the same sectional shape and have substantially the same flow rate of ink.

The space inside the liquid storing chamber **60** located above the inlet DI in the vertical direction functions as a bubble retention space P. The bubble retention space P retains the bubbles (gas) that have passed through the filter F. Although the space inside the liquid storing chamber **60** located above the inlet DI in the vertical direction functions as the bubble retention space P in the embodiment, this configuration should not be construed as limiting the invention. Alternatively, a part of the space inside the liquid storing chamber **60** located above the inlet DI in the vertical direction may function as the bubble retention space P.

In the embodiment, the top of the liquid storing chamber **60** in the vertical direction is in communication with the degassing chamber Q. The degassing chamber Q is a space for decompressing a part of the liquid path D to thereby remove bubbles from ink. The degassing chamber Q also functions as a degassing space where the bubbles (gas) removed from the ink are temporarily retained.

The gas permeable films MA, MB, and MC function as compartments at different positions between the degassing chamber Q and the liquid path D. The positions and number of gas permeable films illustrated in the embodiment should not be construed as limiting the invention. For example, a single gas permeable film may be disposed only at a certain position in the liquid path D (for example, at the illustrated position of the gas permeable film MA). The gas permeable film MA is disposed between the liquid storing chamber **60** and the degassing chamber Q. Each of the gas permeable films MB is disposed between the corresponding common liquid chamber SR and the degassing chamber Q. The gas permeable film MC is disposed between the space **52** and the degassing chamber Q.

Each of the gas permeable films MA, MB, and MC is a film having gas permeability to allow air and other gases but not liquid (for example, ink) to pass therethrough. The gas permeable films MA, MB, and MC are composed of a known polymeric material, for example. The bubbles captured by the filter F are discharged to the degassing chamber Q through the gas permeable film MC and are thus removed from the ink. The bubbles that have passed through the filter F enter the liquid storing chamber **60** from the space **54** through the inlet DI. Then, the bubbles that have entered the liquid storing chamber **60** are also discharged to the degassing chamber Q through the gas permeable film MA.

Each of the common liquid chambers SR has an outlet Rout. The outlet Rout is disposed on a ceiling **49** of the common liquid chamber SR. The ceiling **49** of the common liquid chamber SR is a slanted surface (flat or curved surface) inclined upward from the side of the inlet Rin to the side of the outlet Rout. This slanted ceiling **49** guides the bubbles that have entered through the inlet Rin to the outlet Rout and causes the bubbles to be discharged to the degassing chamber Q through the gas permeable film MB.

The decompression in the air path A with the pump **19** results in decompression in the degassing chamber Q because the degassing chamber Q is in communication with the air path A. The decompression in the degassing chamber Q causes the bubbles in the liquid path D to pass through the gas permeable film MA, MB, or MC. The gas that has been introduced into the degassing chamber Q through the gas permeable film MA, MB, or MC is discharged to the outside of the apparatus through the air path A. The bubbles are thus removed from the liquid path D.

The liquid path D according to the embodiment is provided with a liquid path E for returning the ink in the liquid ejecting head **44** to the side of the liquid ejecting apparatus **10**. The liquid path E is in communication with the internal path in the channel unit **42** for supplying ink to the liquid ejecting head **44**. Specifically, the liquid path E is in communication with the outlets Rout of the common liquid chambers SR of the liquid ejecting head **44**. The liquid path E is connected to a circulating mechanism **47** through the channel component **46**. The circulating mechanism **47** includes a circulating path and a pump, for example. The circulating mechanism **47** has a circulating function of returning the ink discharged along the liquid path E to the side of the liquid ejecting apparatus **10**, so that the ink can be reused in the liquid ejecting head **44**.

In the above-described configuration illustrated in FIG. **3**, when the valve body **722** of the valve mechanism **70** opens, the ink from the liquid container **14** flows through the filter chamber **50** and enters the liquid storing chamber **60** through the inlet DI. The ink exits the liquid storing chamber **60** through one or both of the first outlet DO**1** and the second outlet DO**2**. In the case of ink ejection by driving the piezoelectric elements **484** associated with the first nozzle array L**1**, the ink in the liquid storing chamber **60** flows into the common liquid chamber SR associated with the first nozzle array L**1** through the first outlet DO**1**, is supplied to the individual pressure chambers SC through the opening **481**A, and is then ejected from the nozzles N of the first nozzle array L**1**. In the case of ink ejection by driving the piezoelectric elements **484** associated with the second nozzle array L**2**, the ink in the liquid storing chamber **60** flows into the common liquid chamber SR associated with the second nozzle array L**2** through the second outlet DO**2**, is supplied to the individual pressure chambers SC through the opening **481**A, and is then ejected from the nozzles N of the second nozzle array L**2**.

Most of the bubbles contained in ink are captured by the filter F but some may pass through the filter F. In the embodiment, the liquid storing chamber **60** disposed downstream of the filter F can receive the bubbles through the inlet DI that have passed through the filter F. These bubbles in the liquid storing chamber **60** rise due to buoyancy and are retained in the bubble retention space P. The configuration according to the embodiment can cause the bubbles that have passed through the filter F to be retained in the bubble retention space P and thus suppress the bubbles from flowing into the liquid ejecting head **44** and its nozzles N through the first outlet DO**1** or the second outlet DO**2**.

Some types of ink, however, often generate by-products (for example, an aggregate of a pigment and a binder resin) due to evaporation of the solvent of the ink, for example, at the air-liquid interface where the ink is in contact with the bubbles retained in the bubble retention space P. For example, types of ink having a high solid content concentration readily generate solid materials due to evaporation of the ink solvent. In addition, types of quick-drying ink applicable to a medium **11** (for example, a plastic film) having a low ink absorption property, other than a medium **11** (for example, a paper sheet) having a high ink absorption property, also readily generate solid materials because of the quick-drying property of the ink solvent. As the specific gravity of a by-product generated in the bubble retention space P increases above the specific gravity of the solvent, the by-product more readily sinks below the bubble retention space P and is accumulated on a bottom **62** of the liquid storing chamber **60**. In particular, types of ink containing pigments having bright and durable colors generate solid materials that are readily accumulated because the pigments tend to have a higher specific gravity than that of the ink solvent.

The filter F can remove the by-products generated upstream of the filter F (for example, in the space **52**) but cannot remove the by-products generated in the bubble retention space P downstream of the filter F. Such remaining by-products may enter the liquid ejecting head **44** and its nozzles N, resulting in irregular ejection.

To solve this problem, the liquid storing chamber **60** according to the embodiment has the first outlet DO**1** and the second outlet DO**2** on both sides of an imaginary center line O'-O' illustrated in FIG. **4** (described below) as viewed in the vertical direction (Z direction). The imaginary center line O'-O' is a straight line extending in the Y direction and passing through a center O of a projected area P', which is defined by projecting the bubble retention space P onto the bottom **62** of the liquid storing chamber **60** in the vertical direction. It should be noted that the imaginary center line O'-O' is not necessarily a straight line extending in the Y direction. In this configuration, the ink exits the liquid storing chamber **60** through the first outlet DO**1** and the second outlet DO**2**, thereby generating ink flows having components in the opposite directions from the imaginary center line O'-O' of the projected area P' to the first outlet DO**1** and the second outlet DO**2**. The ink flow components in the opposite directions cancel movements of the by-products accumulated in the projected area P' and thus suppress the by-products from reaching the first outlet DO**1** or the second outlet DO**2**. Accordingly, the configuration according to the embodiment can suppress the by-products generated in the bubble retention space P downstream of the filter F from flowing into the liquid ejecting head **44** and its nozzles N through the first outlet DO**1** or the second outlet DO**2**.

The configuration according to the embodiment will now be described in detail with reference to the accompanying drawings. FIG. **4** illustrates sections of the liquid storing chamber **60** illustrated in FIG. **3**. The upper half of FIG. **4** is a sectional view of the filter chamber **50** and the liquid storing chamber **60** taken along the XZ plane, while the lower half is a sectional view taken along line IV-IV in the upper sectional view. With reference to FIG. **4**, the liquid storing chamber **60** is disposed downstream of the filter chamber **50**. The bubble retention space P of the liquid storing chamber **60** is located above the inlet DI in the vertical direction. The bottom **62** of the liquid storing chamber **60** is located below the bubble retention space P in the vertical direction. In the lower sectional view of FIG. **4**, the projected area P' is defined by projecting the bubble retention space P onto the bottom **62** in the vertical direction. The first outlet DO**1** is located on one side (the negative side in the X direction) of the imaginary center line O'-O' passing through the center O of the projected area P', while the second outlet DO**2** is located on the other side (the positive side in the X direction) of the imaginary center line O'-O'.

With reference to FIG. **4**, the first outlet DO**1** and the second outlet DO**2** are located outside the projected area P'. This arrangement can suppress the by-products sinking from the bubble retention space P from reaching the first outlet DO**1** or the second outlet DO**2**. The arrangement can thus suppress the by-products generated in the bubble retention space P downstream of the filter F from flowing into the liquid ejecting head **44** and its nozzles N through the first outlet DO**1** or the second outlet DO**2**. It should be noted that the arrangement illustrated in FIG. **4** is a mere example. The first outlet DO**1** and the second outlet DO**2** may also be located inside the projected area P'.

In the embodiment, the first outlet DO**1** and the second outlet DO**2** are located on both sides of the imaginary center line O'-O' passing through the center O of the projected area P'. This arrangement can readily generate ink flow components in the opposite directions. The ink flow components in the opposite directions cancel movements of the by-products that have sunk from the bubble retention space P onto the bottom **62** and been accumulated in the projected area P' and thus suppress the by-products from reaching the first outlet DO**1** or the second outlet DO**2**. This configuration can thus suppress the by-products from flowing into the liquid ejecting head **44** and its nozzles N. In the configuration illustrated in FIG. **4**, the direction from the center O of the projected area P' to the second outlet DO**2** is opposite to the direction from the center O of the projected area P' to the first outlet DO**1**, as viewed in the vertical direction. The first outlet DO**1** and the second outlet DO**2** are thus symmetrical to each other about the imaginary center line O'-O'. This arrangement can readily generate ink flow components in the opposite directions from the center O of the projected area P', thereby effectively suppressing the by-products accumulated in the projected area P' from reaching the first outlet DO**1** or the second outlet DO**2**.

The liquid storing chamber **60** illustrated in FIG. **4** has a section that is orthogonal to the vertical direction of the liquid storing chamber **60** and is located below the bubble retention space P in the vertical direction. This cross section has a smaller area than that of the bottom **62**. Although the liquid storing chamber **60** illustrated in FIG. **4** has a truncated pyramid shape of which the rectangular section orthogonal to the vertical direction becomes larger in the positive Z direction, this configuration should not be construed as limiting the invention. For example, the liquid storing chamber **60** may also have a truncated triangular pyramid shape having a triangular section or a truncated cone shape having a circular section.

Since the liquid storing chamber **60** has a section located below the bubble retention space P in the vertical direction and having a smaller area than that of the bottom **62**, the projected area P' of the bubble retention space P can have a smaller area T than the area T' of the bottom **62**. This configuration can cause the by-products sinking from the bubble retention space P to be readily accumulated in the vicinity of the center O of the projected area P'. That is, the configuration can keep the by-products accumulated in the projected area P' away from the first outlet DO**1** and the second outlet DO**2**, thereby suppressing the by-products from flowing out through the first outlet DO**1** or the second outlet DO**2**.

In the embodiment, the first outlet DO**1** and the second outlet DO**2** are located below the inlet DI in the vertical direction. This configuration can provide a larger bubble retention space P and can more readily guide bubbles into the bubble retention space P using buoyancy, compared with the configuration including the first outlet DO**1** and the second outlet DO**2** located above the inlet DI. Furthermore, the first outlet DO**1** and the second outlet DO**2** are located below the center of the liquid storing chamber **60** in the vertical direction in the embodiment. This configuration can provide a larger bubble retention space P and can more readily guide bubbles into the bubble retention space P using buoyancy, compared with the configuration including the first outlet DO**1** and the second outlet DO**2** located above the center of the liquid storing chamber **60**.

A method of driving the liquid ejecting apparatus **10** according to the first embodiment will now be explained with reference to the accompanying drawings. FIG. **5** is a flowchart illustrating a method of driving the liquid ejecting apparatus **10** during a printing operation and a cleaning operation. The cleaning operation indicates a maintenance operation for discharging the by-products accumulated on the bottom **62** of the liquid storing chamber **60** from the nozzles N of the liquid ejecting head **44**. FIG. **6** illustrates a process in the liquid storing chamber **60** during the printing operation. The upper half of FIG. **6** is a sectional view of the filter chamber **50** and the liquid storing chamber **60** taken along the XZ plane, while the lower half is a sectional view taken along line VI-VI in the upper sectional view. FIG. **7** illustrates a process in the liquid storing chamber **60** during the cleaning operation. The upper half of FIG. **7** is a sectional view of the filter chamber **50** and the liquid storing chamber **60** taken along the XZ plane, while the lower half is a sectional view taken along line VII-VII in the upper sectional view.

With reference to FIG. **5**, the controller **12** determines which operation (the printing operation or the cleaning operation) to execute next in Step S**11**. If the controller **12** determines to execute the printing operation next in Step S**11**, the printing operation involving ink ejection through both of the first outlet DO**1** and the second outlet DO**2** is executed in Step S**12**. Specifically, the controller **12** selectively supplies driving pulses to the piezoelectric elements **484** associated with the first nozzle array L**1** and the second nozzle array L**2** in accordance with received print data. Then, as indicated by solid arrows in FIG. **6**, the ink that has passed through the filter F and entered the liquid storing chamber **60** flows into the liquid ejecting head **44** and its nozzles N through both of the first outlet DO**1** and the second outlet DO**2** and is then ejected from the nozzles N of the first nozzle array L**1** and the second nozzle array L**2**.

The bubbles Bu that have passed through the filter F enter the liquid storing chamber **60** through the inlet DI, rise due to buoyancy, and are then retained in the bubble retention space P. These bubbles Bu retained in the bubble retention space P and ink form an air-liquid interface PA in the bubble retention space P. If by-products K are generated at the air-liquid interface PA, as illustrated in the upper sectional view of FIG. **6**, the by-products K sink onto the bottom **62** and are accumulated in the projected area P', as illustrated in the lower sectional view of FIG. **6**.

In the embodiment, the ink flows out through the first outlet DO**1** and the second outlet DO**2**, thereby generating ink flows having components in the opposite directions from the imaginary center line O'-O' of the projected area P' to the first outlet DO**1** and the second outlet DO**2** (as indicated by solid arrows in the lower sectional view of FIG. **6**). The ink flow components in the opposite directions cancel movements of the by-products K accumulated in the projected area P' and thus suppress the by-products K from reaching the first outlet DO**1** or the second outlet DO**2**. This configuration can thus suppress the by-products K from flowing into the liquid ejecting head **44** and its nozzles N through the first outlet DO**1** or the second outlet DO**2**.

In the embodiment, the degassing chamber Q is disposed above the bubble retention space P in the vertical direction and degases the liquid with the gas permeable film MA. This configuration can cause the bubbles Bu retained in the bubble retention space P to be discharged to the degassing chamber Q. The configuration can thus reduce the generation of by-products K at the air-liquid interface PA between the bubbles Bu and the ink in the bubble retention space P. In addition, the projected area P' of the air-liquid interface PA gradually becomes smaller during discharge of the bubbles Bu from the liquid storing chamber **60** according to the embodiment. This configuration can keep the by-products K generated at the air-liquid interface PA further away from the first outlet DO**1** and the second outlet DO**2**.

If the controller **12** determines to execute the cleaning operation next in Step S**11**, the cleaning operation involving ink ejection through one of the first outlet DO**1** and the second outlet DO**2** is executed in Step S**13**. Specifically, the nozzles N on the ejection surface of the liquid ejecting head **44** are capped with a cap (not shown) and then vacuumed using a pump (not shown).

For example, only the first nozzle array L**1** is capped without the capping of the second nozzle array L**2**, so that the ink flows out through the first outlet DO1. This process generates only an ink flow from the center O of the projected area P' to the first outlet DO1, as indicated by solid arrows in FIG. 7. This ink flow brings the by-products K accumulated in the projected area P' to the first outlet DO1 to be discharged.

Alternatively, only the second nozzle array L2 may be capped without the capping of the first nozzle array L1, so that the ink flows out through the second outlet DO2. This process generates only an ink flow from the center O of the projected area P' to the second outlet DO2. This ink flow brings the by-products K accumulated in the projected area P' to the second outlet DO2 to be discharged.

Although the bottom 62 of the liquid storing chamber 60 has a rectangular shape in the first embodiment, this configuration should not be construed as limiting the invention. For example, with reference to FIG. 8, the bottom 62 of the liquid storing chamber 60 may have a rhombus shape. FIG. 8 is a sectional view for illustrating the bottom 62 of the liquid storing chamber 60 according to a first modification of the first embodiment. The rhombus bottom 62 illustrated in FIG. 8 may have a first outlet DO1 and a second outlet DO2 each of which is located at one of opposite vertices of the rhombus bottom 62. The first outlet DO1 and the second outlet DO2 can thus be located away from the projected area P'.

In the configuration illustrated in FIG. 8, the ink flows out through the first outlet DO1 and the second outlet DO2, thereby generating ink flows having components in the opposite directions from the imaginary center line O'-O' of the projected area P' to the first outlet DO1 and the second outlet DO2. The ink flow components in the opposite directions cancel movements of the by-products accumulated in the projected area P' and thus suppress the by-products from reaching the first outlet DO1 or the second outlet DO2. This configuration can suppress the by-products from flowing into the liquid ejecting head 44 and its nozzles N.

Alternatively, with reference to FIG. 9, the liquid storing chamber 60 may have a truncated triangular pyramid shape having a triangular bottom 62. FIG. 9 is a sectional view for illustrating the bottom 62 of the liquid storing chamber 60 according to a second modification of the first embodiment. The triangular bottom 62 illustrated in FIG. 9 may have a first outlet DO1 located at the vertex on one side of the imaginary center line O'-O' and two second outlets DO2 located at the two respective vertices on the other side. That is, the bottom 62 has one first outlet DO1 and two second outlets DO2. The first outlet DO1 and the second outlets DO2 can thus be located away from the projected area P'.

In the configuration illustrated in FIG. 9, the ink flows out through the first outlet DO1 and the second outlets DO2, thereby generating ink flows having components in different directions from the imaginary center line O'-O' of the projected area P' to the first outlet DO1 and the second outlets DO2. The ink flow components in different directions cancel movements of the by-products accumulated in the projected area P' and thus suppress the by-products from reaching the first outlet DO1 or the second outlet DO2. This configuration can suppress the by-products from flowing into the liquid ejecting head 44 and its nozzles N.

Second Embodiment

A second embodiment of the invention will now be described. In the following embodiments, components having operations and functions identical to those of the components in the first embodiment are provided with the same reference characters as in the first embodiment and description thereof is omitted, as appropriate. FIG. 10 illustrates sections of the liquid storing chamber 60 according to the second embodiment. The upper half of FIG. 10 is a sectional view of the filter chamber 50 and the liquid storing chamber 60 taken along the XZ plane, while the lower half is a sectional view taken along line X-X in the upper sectional view.

The bottom 62 of the liquid storing chamber 60 illustrated in FIG. 10 is provided with a restricting portion 64 at least between the first outlet DO1 and the projected area P' and between the second outlet DO2 and the projected area P', as viewed in the vertical direction. The restricting portion 64 restricts movement of the by-products K accumulated on the bottom 62. The restricting portion 64 illustrated in FIG. 10 is a recess including the projected area P' on the bottom 62. That is, the projected area P' is located inside the recess functioning as the restricting portion 64, while the first outlet DO1 and the second outlet DO2 are located outside the recess. The restricting portion 64 defines walls (inner walls of the recess functioning as the restricting portion 64) higher than the projected area P' around the projected area P'. The inner walls of the restricting portion 64 can suppress the by-products K from approaching the first outlet DO1 or the second outlet DO2 over the restricting portion 64 regardless of the occurrence of an ink flow on the bottom 62 that brings the by-products K. This configuration can more effectively suppress the by-products K from flowing into the liquid ejecting head 44, compared with the configuration without the restricting portion 64.

The restricting portion 64 may have a configuration other than the configuration illustrated in FIG. 10. For example, with reference to FIG. 11, the restricting portion 64 may be a ring-shaped protrusion surrounding the projected area P' on the bottom 62. FIG. 11 illustrates sections of the liquid storing chamber 60 according to a first modification of the second embodiment. The upper half of FIG. 11 is a sectional view of the filter chamber 50 and the liquid storing chamber 60 taken along the XZ plane, while the lower half is a sectional view taken along line XI-XI in the upper sectional view. With reference to FIG. 11, the projected area P' is located inside the ring-shaped protrusion functioning as the restricting portion 64, while the first outlet DO1 and the second outlet DO2 are located outside the ring-shaped protrusion. The restricting portion 64 defines walls (inner walls of the ring-shaped protrusion functioning as the restricting portion 64) higher than the projected area P' around the projected area P'. The inner walls of the restricting portion 64 can suppress the by-products K from approaching the first outlet DO1 or the second outlet DO2 over the restricting portion 64 regardless of the occurrence of an ink flow on the bottom 62 that brings the by-products K. This configuration can more effectively suppress the by-products K from flowing into the liquid ejecting head 44, compared with the configuration without the restricting portion 64.

Alternatively, with reference to FIG. 12, the restricting portion 64 may be a ring-shaped groove surrounding the projected area P' on the bottom 62. FIG. 12 illustrates sections of the liquid storing chamber 60 according to a second modification of the second embodiment. The upper half of FIG. 12 is a sectional view of the filter chamber 50 and the liquid storing chamber 60 taken along the XZ plane, while the lower half is a sectional view taken along line XII-XII in the upper sectional view. With reference to FIG. 12, the projected area P' is located inside the ring-shaped groove functioning as the restricting portion **64**, while the first outlet DO**1** and the second outlet DO**2** are located outside the ring-shaped groove. The ring-shaped groove functioning as the restricting portion **64** around the projected area P' can trap the by-products K and suppress the by-products K from approaching the first outlet DO**1** or the second outlet DO**2** over the ring-shaped groove regardless of the occurrence of an ink flow on the bottom **62** that brings the by-products K. This configuration can more effectively suppress the by-products K from flowing into the liquid ejecting head **44**, compared with the configuration without the restricting portion **64**.

Third Embodiment

A third embodiment of the invention will now be described. Although the first outlet DO**1** and the second outlet DO**2** are provided to the bottom **62** of the liquid storing chamber **60** in the first and second embodiments, the first outlet DO**1** and the second outlet DO**2** are provided to side surfaces **63** of the liquid storing chamber **60** in the third embodiment. FIG. **13** illustrates sections of the liquid storing chamber **60** according to the third embodiment. The upper half of FIG. **13** is a sectional view of the filter chamber **50** and the liquid storing chamber **60** taken along the XZ plane, while the lower half is a sectional view taken along line XIII-XIII in the upper sectional view.

With reference to FIG. **13**, the first outlet DO**1** is provided to the side surface **63** on the negative side in the X direction, while the second outlet DO**2** is provided to the side surface **63** on the positive side in the X direction. The first outlet DO**1** and the second outlet DO**2** are thus spaced from the bottom **62** in the vertical direction. This configuration can more effectively suppress the by-products accumulated on the bottom **62** from flowing out through the first outlet DO**1** or the second outlet DO**2** and can more effectively suppress the by-products sinking from the bubble retention space P from reaching the first outlet DO**1** or the second outlet DO**2**, compared with the configuration including the first outlet DO**1** and the second outlet DO**2** provided to the bottom **62**.

In the configuration illustrated in FIG. **13**, the first outlet DO**1** and the second outlet DO**2** are located on both sides of the imaginary center line O'-O' passing through the center O of the projected area P' of the bubble retention space P, as viewed in the vertical direction. This arrangement generates ink flows having components in the opposite directions from the imaginary center line O'-O' of the projected area P' to the first outlet DO**1** and the second outlet DO**2**. The ink flow components in the opposite directions cancel movements of the by-products accumulated in the projected area P' and thus suppress the by-products from being displaced. The configuration illustrated in FIG. **13** can thus effectively suppress the by-products from flowing into the liquid ejecting head **44** and its nozzles N through the first outlet DO**1** or the second outlet DO**2**.

The first outlet DO**1** and the second outlet DO**2** illustrated in FIG. **13** are located below the center of the liquid storing chamber **60** in the vertical direction. This configuration can provide a larger bubble retention space P, compared with the configuration including the first outlet DO**1** and the second outlet DO**2** located above the center of the liquid storing chamber **60**. It is preferable that the first outlet DO**1** and the second outlet DO**2** be located near the bottom **62**, for example, at a height equal to or lower than one quarter or one fifth of the height of the liquid storing chamber **60** in the vertical direction (that is, the distance from the bottom **62** to the ceiling of the liquid storing chamber **60** in the Z direction).

Fourth Embodiment

A fourth embodiment of the invention will now be described. Although the liquid storing chamber **60** is provided with the degassing chamber Q in the first to third embodiments, no degassing chamber Q is provided in the fourth embodiment. FIG. **14** illustrates sections of the liquid storing chamber **60** according to the fourth embodiment. The upper half of FIG. **14** is a sectional view of the filter chamber **50** and the liquid storing chamber **60** taken along the XZ plane, while the lower half is a sectional view taken along line XIV-XIV in the upper sectional view. With reference to FIG. **14**, the liquid storing chamber **60** is not provided with a gas permeable film MA or a degassing chamber Q. The other structures are identical to those illustrated in FIG. **4**. In the configuration illustrated in FIG. **14**, the nozzles N are vacuumed during the cleaning operation to discharge the bubbles retained in the bubble retention space P in the liquid storing chamber **60**.

Alternatively, as in a modification of the fourth embodiment illustrated in FIG. **15**, the liquid storing chamber **60** may have a bottle neck **66**. FIG. **15** illustrates sections of the liquid storing chamber **60** according to the modification of the fourth embodiment. The upper half of FIG. **15** is a sectional view of the filter chamber **50** and the liquid storing chamber **60** taken along the XZ plane, while the lower half is a sectional view taken along line XV-XV in the upper sectional view. The liquid storing chamber **60** illustrated in FIG. **15** has a shape defined by bonding two truncated pyramids in the opposite orientations to each other. The joint between the two truncated pyramids corresponds to the bottle neck **66**.

Specifically, the liquid storing chamber **60** illustrated in FIG. **15** is composed of a lower truncated pyramid **602** of which the section orthogonal to the vertical direction gradually becomes larger in the positive Z direction, and an upper truncated pyramid **604** of which the section orthogonal to the vertical direction gradually becomes larger in the negative Z direction. With reference to FIG. **15**, the upper truncated pyramid **604** has an inlet DI, while the lower truncated pyramid **602** has a first outlet DO**1** and a second outlet DO**2** on the bottom **62**. In the configuration illustrated in FIG. **15**, the space of the upper truncated pyramid **604** located above the inlet DI in the vertical direction functions as a bubble retention space P.

The bottle neck **66** illustrated in FIG. **15** has a smallest section t having the minimum area below the bubble retention space P in the vertical direction among the cross sections orthogonal to the vertical direction of the liquid storing chamber **60**. Because of the bottle neck **66** having the smallest section t below the bubble retention space P in the vertical direction, the configuration can provide a larger section to the bubble retention space P than the smallest section t. Furthermore, regardless of the larger bubble retention space P, the by-products generated in the bubble retention space P sink through the smallest section t of the bottle neck **66** before arriving at the bottom **62**. This configuration can cause the by-products to be accumulated in an area t' defined by projecting the smallest section t of the bottle neck **66** onto the bottom **62**, which is smaller than the projected area P' of the bubble retention space P. That is, the configuration can keep the by-products accumulated in the projected area P' away from the first outlet DO**1** and the second outlet DO**2**, thereby suppressing the by-products from flowing out.

In the configuration illustrated in FIG. **15**, by-products are accumulated in the area t' smaller than the projected area P' of the bubble retention space P. Accordingly, the first outlet DO**1** and the second outlet DO**2** are only required to be located at least outside the area t'. The configuration can suppress the by-products from reaching the first outlet DO**1** or the second outlet DO**2**.

Modifications

The above-illustrated aspects and embodiments may be modified in various manners. Some specific exemplary modifications will be described below. Any two or more of these modifications and the above embodiments may be appropriately combined with each other provided that there are no contradictions.

(1) The above embodiments are directed at a serial head printer in which the carriage **18** provided with the liquid ejecting head **44** thereon reciprocates in the X direction. The invention may also be applied to a line head printer including a liquid ejecting head **44** spanning the entire width of a medium **11**.

(2) In the above embodiments, the liquid ejecting head **44** is of a piezoelectric type and includes the piezoelectric elements for providing mechanical oscillation to the pressure chambers. This liquid ejecting head **44** may be replaced with a thermal-type liquid ejecting head that includes heater elements for generating heat to cause bubbles in pressure chambers.

(3) The liquid ejecting apparatus **10** illustrated in the above embodiments may be applied to various types of machines, such as facsimile and copying machines, in addition to machines dedicated to printing. It should be noted that the liquid ejecting apparatus **10** according to the invention may be used for purposes other than printing. For example, liquid ejecting apparatuses that eject solutions of color filter materials can be used in the manufacture of, for example, color filters of liquid crystal displays, organic electroluminescence (EL) displays, and field emission displays (FEDs). Liquid ejecting apparatuses that eject a solution of conductive material can be used to form wiring and electrodes of circuit boards. Furthermore, liquid ejecting apparatuses that eject a solution of bioorganic material (a type of liquid) can be used as chip manufacturing apparatuses.

What is claimed is:

1. A liquid ejecting apparatus comprising:

a filter disposed in a liquid path for supplying liquid to nozzles of a liquid ejecting head; and

a liquid storing chamber disposed downstream of the filter in the liquid path, the liquid storing chamber including:

an inlet through which the liquid enters the liquid storing chamber;

a bubble retention space disposed above the inlet in the vertical direction;

a bottom disposed below the bubble retention space in the vertical direction; and

a first outlet and a second outlet through which the liquid exits the liquid storing chamber, wherein

the liquid ejecting apparatus satisfies one of conditions (i) and (ii) below:

(i) the first outlet is located on one side of an imaginary center line and the second outlet is located on the other side of the imaginary center line, as viewed in the vertical direction, the imaginary center line passing through a center of a projected area, the projected area being defined by projecting the bubble retention space onto the bottom in the vertical direction; and

(ii) the first outlet and the second outlet are located outside a projected area, as viewed in the vertical direction, the projected area being defined by projecting the bubble retention space onto the bottom in the vertical direction.

2. The liquid ejecting apparatus according to claim **1**, wherein a direction from the center of the projected area to the second outlet is opposite to a direction from the center of the projected area to the first outlet, as viewed in the vertical direction.

3. The liquid ejecting apparatus according to claim **1**, wherein the liquid storing chamber has a section orthogonal to the vertical direction below the bubble retention space in the vertical direction, the section having an area smaller than an area of the bottom.

4. The liquid ejecting apparatus according to claim **3**, wherein the liquid storing chamber has a section orthogonal to the vertical direction below the bubble retention space in the vertical direction, the section having the smallest area.

5. The liquid ejecting apparatus according to claim **1**, wherein the bottom comprises a restricting portion disposed at least between the first outlet and the projected area and between the second outlet and the projected area, as viewed in the vertical direction, the restricting portion being configured to restrict movement of by-products accumulated on the bottom.

6. The liquid ejecting apparatus according to claim **3**, wherein the first outlet and the second outlet are located below the inlet in the vertical direction.

7. The liquid ejecting apparatus according to claim **6**, wherein the first outlet and the second outlet are located below a center of the liquid storing chamber in the vertical direction.

8. The liquid ejecting apparatus according to claim **3**, further comprising:

a degassing chamber disposed above the bubble retention space in the vertical direction, the degassing chamber being configured to degas the liquid with a gas permeable film.

9. The liquid ejecting apparatus according to claim **3**, wherein the liquid is caused to exit the liquid storing chamber through one of the first outlet and the second outlet so as to generate a flow of the liquid on the bottom.

10. The liquid ejecting apparatus according to claim **3** that satisfies the condition (i).

11. The liquid ejecting apparatus according to claim **3** that satisfies the condition (ii).

12. A method of driving a liquid ejecting apparatus, the liquid ejecting apparatus including:

a filter disposed in a liquid path for supplying liquid to nozzles of a liquid ejecting head; and

a liquid storing chamber disposed downstream of the filter in the liquid path, the liquid storing chamber including:

an inlet through which the liquid enters the liquid storing chamber;

a bubble retention space disposed above the inlet in the vertical direction;

a bottom disposed below the bubble retention space in the vertical direction; and

a first outlet and a second outlet through which the liquid exits the liquid storing chamber, the first outlet being located on one side of an imaginary center line and the second outlet being located on the other side of the imaginary center line, as viewed in the vertical direction, the imaginary center line passing through a center of a projected area, the projected area being defined by projecting the bubble retention space onto the bottom in the vertical direction,

the method comprising causing the liquid to exit the liquid storing chamber through the first outlet and the second outlet.

13. A method of driving a liquid ejecting apparatus, the liquid ejecting apparatus including:

a filter disposed in a liquid path for supplying liquid to nozzles of a liquid ejecting head; and

a liquid storing chamber disposed downstream of the filter in the liquid path, the liquid storing chamber including:

an inlet through which the liquid enters the liquid storing chamber;

a bubble retention space disposed above the inlet in the vertical direction;

a bottom disposed below the bubble retention space in the vertical direction; and

a first outlet and a second outlet through which the liquid exits the liquid storing chamber, the first outlet and the second outlet being located outside a projected area, as viewed in the vertical direction, the projected area being defined by projecting the bubble retention space onto the bottom in the vertical direction,

the method comprising causing the liquid to exit the liquid storing chamber through the first outlet and the second outlet.

14. The method of driving the liquid ejecting apparatus according to claim **12**, wherein

the liquid ejecting apparatus further includes a degassing chamber disposed above the bubble retention space in the vertical direction, the degassing chamber being configured to degas the liquid with a gas permeable film, and

the method further comprises discharging bubbles retained in the bubble retention space to the degassing chamber.

15. The method of driving the liquid ejecting apparatus according to claim **12**, further comprising:

causing the liquid to exit the liquid storing chamber through one of the first outlet and the second outlet and generating a flow of the liquid on the bottom.

16. The liquid ejecting apparatus according to claim **1**, further comprising:

a degassing chamber disposed above the bubble retention space in the vertical direction, the degassing chamber being configured to degas the liquid with a gas permeable film.

17. The liquid ejecting apparatus according to claim **1**, wherein the liquid is caused to exit the liquid storing chamber through one of the first outlet and the second outlet so as to generate a flow of the liquid on the bottom.

18. The liquid ejecting apparatus according to claim **1** that satisfies the condition (i).

19. The liquid ejecting apparatus according to claim **1** that satisfies the condition (ii).

20. The liquid ejecting apparatus according to claim **19**, wherein the liquid storing chamber has a section orthogonal to the vertical direction below the bubble retention space in the vertical direction, the section having the smallest area.

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